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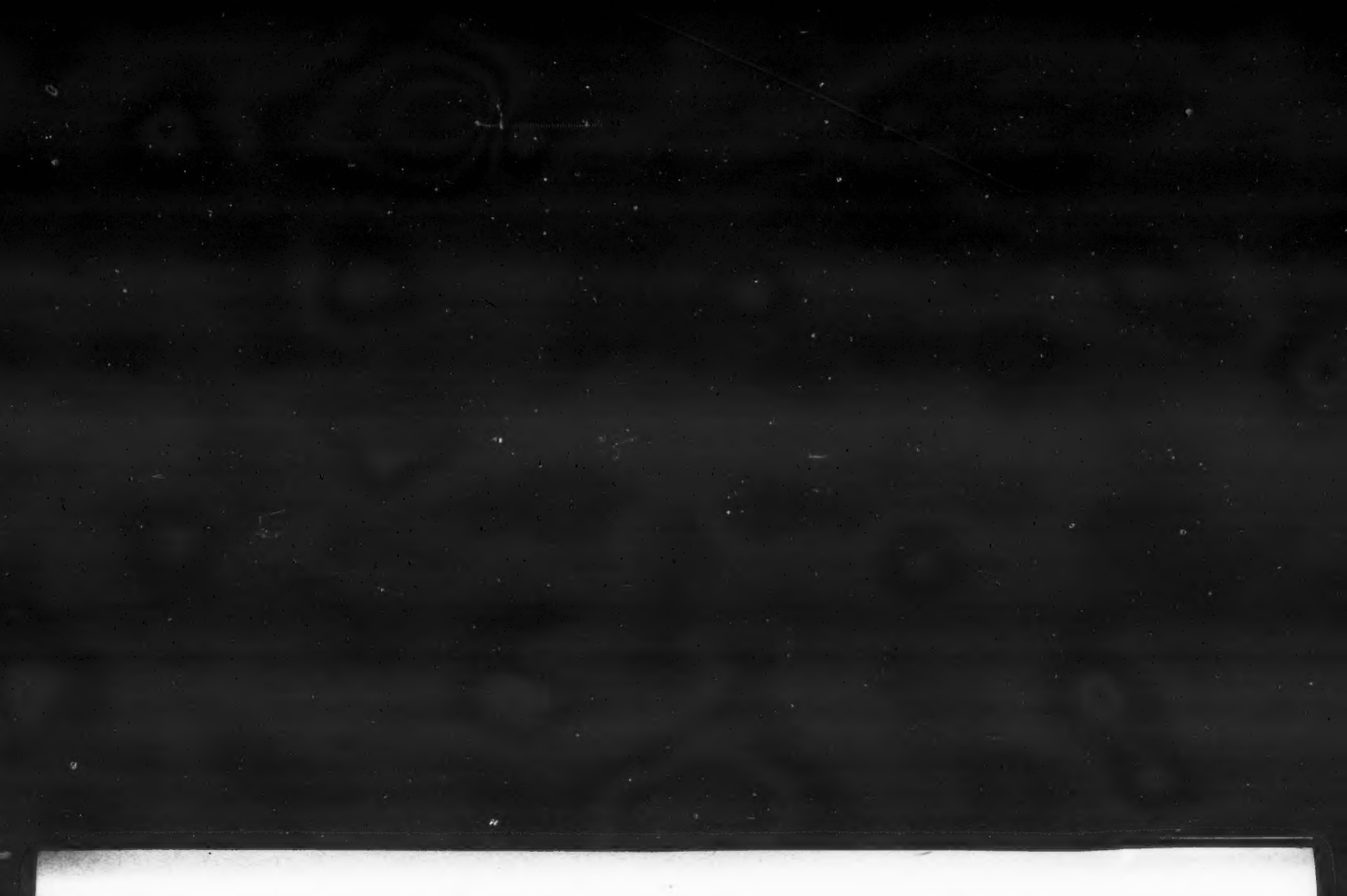


THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. XLI.—*On the Relationship of the Pleistocene to the Pre-pleistocene formations of the Mississippi Basin, south of the limit of glaciation;** by T. C. CHAMBERLIN and R. D. SALISBURY.

THE deposits made by the ice and by the waters which originated from it during the glacial period, possess a character so unique, and so markedly unlike that of the underlying formations within the glaciated area of the United States, that there has been little difficulty in discriminating between them. There have been differences of opinion as to the relative importance of the various agencies which are believed to have been operative in the production of the drift, and in some minor measure these differences still exist. But whether the drift of any particular region be believed to be the work of glaciers, or of icebergs or ice-floes, or of glacio-natant lakes or streams, or the joint work of two or more of these agencies, still the drift, as such, is clearly defined from the underlying strata. In many regions, this is true no less of the valley drift which stretches beyond the glaciated area along the avenues of discharge for the melting ice, than of the unmodified drift upon the extra-valley lands farther to the north, where the drift agent is believed to have been land ice.

* The writers have worked in such close association in the study of this and of correlated regions, that it is difficult to define their individual work and their respective responsibilities; nor is it important; but they have reasons for stating that the preliminary determination of the salient features of the correlation, and the direction of the investigation, are largely the work of Mr. Chamberlin, while the detailed investigation, the elaboration of results, and the preparation of this article are chiefly the work of Mr. Salisbury.

But in the central part of the basin of the Mississippi River below the latitude of glaciation, the difference between the deposits made by the waters originating in the melting ice, and the subjacent strata, appears to be much less obvious than in many other regions. In consequence, the recognition of the Pleistocene formations along the course of the Mississippi south of the limit of the general drift sheet, and therefore the correlation of the northern and southern Pleistocene formations, has not been free from difficulties.

The Loess.—The highlands bordering the Mississippi Valley on either side, between the parallels of 37° 30′ (the southern limit of glacial drift), and 35° are overspread by loess. The loess extends much below this latitude, but that is the lower limit of the area especially under consideration. A belt of loess similarly disposed occurs along the course of the Ohio, for a considerable distance above its junction with the Mississippi, though the loess along this stream is less constant in character, and its facies often different from that of the Mississippi River loess. Consonant with the general habit of this formation, the loess is best developed on the highlands immediately adjacent to the rivers. In such situations, the loess possesses the loose, open texture which is one of its most diagnostic characteristics. As the formation is traced eastward or westward from the Mississippi, or northward or southward from the Ohio, these characteristics gradually disappear. The open texture becomes less pronounced, and by almost imperceptible degrees passes from that of a loose, light loam, through that of a clayey loam, to that of a loamy clay. So far does this gradation proceed, that the texture of the loam at some distance from the streams, resembles much more closely that of the residuary earth upon which it rests, than that of the typical loess, on the immediate borders of the valley.

A change in color accompanies the change in texture. The buffish color which everywhere characterizes the river bluff loess in its normal development, becomes deeper with increasing distance from the streams, so that along the borders of the loess, where the texture has come to simulate closely that of the residuary earths, the color has become notably deeper than on the bluffs immediately fronting the river, and the deepening color has been a constant approximation to the color of the underlying residuary earth.

Accompanying the change in texture and color, are changes in the chemical character of the loess. Near the rivers it almost uniformly contains a considerable percentage of carbonates. Here too, it very generally contains shells, and concretions of calcium carbonate, the one a partial cause, and the other at once an index and a result of its calcareous character.

The shells, the concretions (*loess-kindchen*), and the calcareous nature of the loess, are features not less characteristic, though less universal, than the texture itself. As the texture of the loess becomes closer and its color deeper with increasing distance from the rivers, the proportion of carbonates diminishes, and may entirely disappear before the border of the loess is reached. The shells and concretions are limited to the calcareous portions of the loess, or they may be still more restricted in their distribution.

With increasing distance from the streams goes another change in the composition of the loess. The complex silicates (feldspar, mica, hornblende, augite, etc.), which are found to be very significant ingredients of the formation along the river bluffs, become less and less abundant, as the other normal characteristics disappear. They may be found, however, in the loams remote from the streams, after almost every other true loess feature has disappeared.

The thickness of the loess diminishes regularly with increasing distance from the rivers. So far does this thinning proceed, that at a distance of a few miles from the streams, but a thin mantle remains.

The features thus indicated as pertaining to, and defining the loess in the region under consideration, are the features which characterize it throughout its distribution to the north along the Mississippi, and along its tributaries in Illinois, Missouri, Iowa, Wisconsin and Minnesota, and along the tributaries of the lower Ohio, in Illinois and Indiana.

Throughout much of this territory the loess lies upon the glacial drift. In southern Illinois, for example, the drift for many miles north of its southern boundary is overspread with loess, or with clay-like loam which may be traced into direct continuity with the normal, open-textured, calcareous, shell- and concretion-bearing loess, along the immediate valleys of the streams. Here too, in scores and hundreds of places, especially in southeastern Illinois, it may be seen that the surface of the drift upon which the loess rests, is one which gives no evidence of exposure to the atmosphere before the mantling loess was spread upon it. Had such exposure found place, the fact would have left its record in the oxidation of the exposed surface, or in the accumulation upon it of an old soil, traces of which would still be found beneath the loess. But in southeastern Illinois and the adjacent parts of Indiana, no zone of oxidation, and no vegetable layer, or trace of old soil, separates the loess from the till beneath. It would not be necessary to suppose that such a zone as that here referred to would necessarily be preserved at all points, until the present time. But its universal absence over large areas, under conditions which

must have been favorable for its preservation, had it ever been developed, seems to be conclusive against the hypothesis that it ever existed. That the conditions were favorable for its preservation is proved by *its well-nigh universal presence under the loess immediately south of the drift border, in the same region.*

In many places, it may be clearly seen that the superficial loess-mantle and the stony drift beneath, meet each other in a thin zone of gradation. That is, the pebbles of the drift frequently occur in the basal portion of the mantling loess, in and just above the horizon where the imbedding matrix changes from a gritty clay (till) to a gritless loam or loamy clay (loess). In other places, there is a more or less marked accumulation of drift pebbles* immediately below the loess or its clayey equivalent, marking its junction with the till. Both these relationships find ready explanation in the hypothesis that glacial waters covered the till, and spread the mantle of loess upon it immediately after the ice retreated. And no other hypothesis seems to meet the case. In the judgment of the writers, therefore, the relationship between these two deposits, the till and the loess, as seen in innumerable sections, in southeastern Illinois and southwestern Indiana, is such as to admit of no second interpretation as to their sequence. The loess, in the regions where such sections are found, was deposited immediately after the till, so far as not actually contemporaneous with it. We distinguish other sheets of loess, contemporaneous with other stages of glaciation, and some of these are separated from underlying till by old soils, but these do not require special consideration here. The active agent concerned in the production of the loess is believed to have been water, and the material of the loess was in part derived from the till beneath, and in part from the glacial silt carried southward from the melting ice to the north. The evidence that the loess is really a glacier-made silt, re-worked by water, has been elsewhere discussed.†

The age of the loess covering the drift along its southern border, would seem to be clearly fixed relative to the underlying till. The till of the region belongs to the first glacial epoch, as we have been accustomed to distinguish the glacial epochs,‡ and this loess belongs to the closing stages of the same epoch, after the ice had retreated somewhat, but while the region to the south of its edge was still overspread, in part at least, by waters originating from it.

The first glacial epoch embraces at least two episodes of glaciation, separated by an interval when the climate of the

* *Steinsohle* of the German geologists.

† Sixth Annual Report, U. S. G. S., page 278 et seq. ‡ Loc. cit., page 212.

southern part of the drift-covered area was so far ameliorated as to allow the growth of vegetation upon the drift of the first episode. In southeastern Illinois and the adjacent parts of Indiana, the ice advance of the second episode of the first epoch seems to have been equal to, if it did not exceed, that of the first episode. This seems not to have been the case in some portions of southwestern Illinois, but in southeastern Illinois, and indeed in most of the southern part of the state, the till immediately beneath the loess is referred to the second ice incursion of the first glacial epoch. The loess here under discussion is therefore to be referred to the close of the second glacial episode of the first glacial epoch. But it may be traced across the limit of the drift from north to south. The continuity is complete, and the character of the formation is the same on both sides of the line which marks the limit of ice advance. It is a continuous mantle, overspreading alike the drift border on the north, and the residuary earths which the ice did not disturb, on the south. If, therefore, the age of the loess which covers the drift be first glacial (first episode), the age of that which lies south of the drift, in the area under discussion, is likewise first glacial.

Between the relationship of the loess to the till north of the limit of glaciation, and the relationship of the loess to the residuary earths of the Paleozoic rocks immediately outside the drift, there is one important difference to which reference has already been made. The presence of a weathered and highly oxidized zone, immediately subjacent to the loess, south of the drift limit, is as conspicuous as is its absence to the north. This oxidized zone is the upper surface of the residuary earths. There is in places, a slight admixture of residuary material and loess at the junction of the two. But the body of the residuary earth is clearly separated from the body of the loess. The fact of the existence of a long interval between the loess and the residuary earths beneath, is as clearly indicated on the one hand, as is the fact of the absence of an interval between the loess and the underlying till on the other. The phenomena on each side of the drift limit, strengthen the conclusion drawn from the phenomena on the other.

There is in the nature of the case no manifest reason why the formation of loess should not have accompanied and followed the ice action of the first episode of the first glacial epoch, just as it accompanied and followed the second episode. Assuming this to have been the case, there should be a twofold division of the loess south of the drift, theoretical, if not observable. Such division has been sought for, but without completely satisfactory results, throughout most of the area under consideration. There are a few localities east of the

Mississippi river, as at Memphis, Tenn., where there is some evidence of the division here suggested. The evidence consists in the presence of a thin layer of humus-stained (apparently) loam, between beds of loess, suggesting an old soil. At Forrest City, Ark., there is a similar layer of dark loam, in similar relationships, while at numerous points farther north on Crowley's Ridge, both in Arkansas and Missouri, there is a thin zone of oxidized (red) loam, occupying a corresponding position. The great majority of sections, however, present the aspect of consecutive deposition; at least no positive signs of separate stages of deposition have been observed.*

The Gravels and Sands subjacent to the Loess. ("Orange Sands.")—Beneath the loess, in the southernmost counties of Illinois, in northern and northwestern Kentucky, in western Tennessee, in northeastern Arkansas, and southeastern Missouri, there is a remarkable series of gravels and sands. In portions, at least, of this area, the gravels and sands have been known in geologic literature under the name of Orange Sand. Unfortunately for clearness of understanding, this term has been differently used by different geologists. The Orange Sand or Lagrange formation of Tennessee (Safford), is regarded by Professor Safford as the partial equivalent of Professor Hilgard's Northern Lignitic, and is referred by both geologists to the Tertiary, Safford regarding it as Miocene, though expressing doubt whether it be not older, and Hilgard regarding it as Eocene † The Bluff Gravels of Safford appear to be the Orange Sand of Hilgard, and are classed by both geologists as Quaternary. Within the area under consideration, both the Lagrange or Orange Sands of Safford, and the Bluff Gravels (Safford), or Orange Sands of Hilgard, occur, and both are covered by loess. With the classification of these formations, and with the question of the relations between the Lagrange Sands and the Bluff Gravels, this article does not deal. It has only to do with their pre-pleistocene age, and with the relation of the loess to them. The Bluff Gravels (Safford) occupy the surface (below the loess) of the river bluffs at various points in Tennessee, while the Lagrange Sands occupy the surface farther east. Farther north, however, sands and gravels which appear to be the equivalent of the Bluff Gravels of Tennessee, have a much greater thickness than in the latter state, and it is not altogether clear that they do not include beds below the Bluff Gravels of Safford. Be that as it may, the gravels have a much greater vertical range in Southern Illinois than has been observed by the writers further to the south. The Bluff Gravel formation "consists

* See further the foot note at the close of the article, p. 377.

† This Journal, vol. xli, page 370, 1864.

generally, of coarse yellow and orange sands, with everywhere more or less coarse gravel, and has usually a layer of white or variegated clay at the base. The gravel is . . . . sometimes cemented by oxyd of iron into great blocks of coarse conglomerate."* Setting aside the question as to subdivisions of the gravels and sands and clays, which the geologists of Illinois have seen no good reason for separating,† it is true, generally speaking, that the body of the gravel overlies the sand. More accurately, the gravel predominates above and the sand below, though the gravel is to be found more or less generally distributed through a considerable vertical range, in the formation in southern Illinois.

Within this series, there are often seams and pockets, or even considerable layers of kaolin-like clay, remarkable alike for its irregularity of development and its brightness and variety of coloring. Oftener than otherwise, the clay is in the lower part of the sand and gravel stratum, but many localities are known to the writers where heavy beds of gravel and sand occur below a considerable thickness of clay. In such cases at least, the clay would seem to be of necessity correlated with the sands and gravels.

At several horizons in various localities, the sand becomes more or less coherent from the presence of a fine sticky matrix of earthy material. The matrix may even predominate over the sand, giving rise to a gritty clay or loam, rather than to a sticky sand. Such gritty clays are wholly unlike the kaolin-like clays above noted. The latter are gritless and variegated in color. The clays here designated as gritty, have always a goodly proportion of coarse sand, and are either of a deep red or a brownish color. In these gritty clays there are frequent laminæ of sand, of variable thickness, and these laminæ are often cemented, forming layers of sandstone of considerable hardness. The same is frequently true of laminæ of sand, and even of layers of considerable thickness, within the body of the sand itself, where there is little admixture of earthy material. In all these cases iron oxide is the chief cement.

Induration is not confined to the sand. Not rarely portions of the gravel are cemented into a firm conglomerate, the cementing material being the same as in the case of the sand. More commonly than otherwise, it is the uppermost portion of the gravel which has been indurated, but there are so many exceptions that this can hardly be said to be the rule. The thickest beds of conglomerate which have been seen by the writers (near Metropolis, Ill.) occur at a low horizon, and (though not shown in vertical section) beneath considerable thicknesses of sand, clay, and loose gravel.

* Safford, this Journal, vol. xxxvii, page 371, 1864.
† Engelman, vol. i, Geol. Surv., iii, page 423.

It is a peculiarity of the distribution of loess, that elevations within the area of its occurrence seem to be no obstacle to its presence. The loess is quite as likely to find its normal development on the higher lands as on the lower. Within the area especially under consideration, the same may be said concerning the gravels. They exist on the highest hills, under the loess, and in fact, speaking generally, find there their best development. The gravels are frequently absent from the slopes of the hills, or but meagerly developed upon them, even when present in quantity upon their crests. These sands and gravels, or at least the portion of them known under the name of Orange Sand (Hilgard), have heretofore generally been regarded as Quaternary, and have even been referred to the Champlain epoch.*

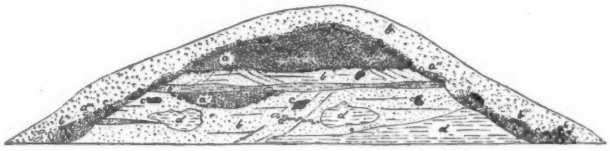
We have already seen, however, that the evidence is conclusive that the loess is to be referred to the melting waters of the first glacial epoch, and the Orange Sand, so far from being referred to a time subsequent to the second glacial epoch, must be referred to a time earlier than the closing stages of the first glacial. How much earlier?

It would not be irrational to suppose that the waters of the melting ice might carry down, along the courses which they followed, great quantities of detritus. Gravel and sand might thus be distributed wherever the currents were strong enough to carry them, conceivably for great distances south of the limit of ice advance, just as gravels are carried far beyond the ends of glaciers to-day by the streams issuing from them. The Mississippi valley must have been an avenue for the discharge of glacio-natant waters, and it would not be strange were glacial gravels found in the same, beyond the extra-valley drift limit, just as glacial gravels, originating from the ice of the second epoch, are found down the valleys far beyond the limit of ice advance at that time. Were the Orange sands and gravels formed in the manner above indicated, and at the time which this origin would necessitate, viz: in the first glacial epoch, we might find evidence of the fact along three several lines, any one of which would be conclusive.

If the gravels be referable to the time of glaciation immediately preceding the deposit of the loess, we should find the loess spread over these gravels conformably, or with only such slight unconformity as might have been developed locally in the interval between the deposition of the gravels, when the

* Hilgard: Agriculture and Geology of Mississippi, 1860. Also this Journal, vol. xli, page 311, 1866. Safford: *Ibid.* vol. xxvii, page 361, 1864. Dana: Manual of Geology, 3d edition, page 548. LeConte's Elements of Geology, page 540. Loughridge: Kentucky Geol. Surv. Jackson Purchase Region, 1888, page 57 *et seq.* By the Geological Survey of Illinois, the formation in question has been regarded as Tertiary. Vol i, page 417, *et seq.*, and page 447, *et seq.*

streams must have been active, and the deposition of the loess, when the streams must have been sluggish. In point of fact such conformity, or so much of conformity as this hypothesis would demand, does not exist. The following diagrammatic section shows the relationship which may be seen to exist between the loess and the gravels and sands, at numerous points in southern Illinois.



Loess (*l*) covers the whole hill. Beneath it, the hill is capped with gravel (*a*). This constitutes a well developed layer, several feet in thickness. The pebbles composing this layer almost uniformly lie upon their surfaces of greatest diameter, and appear to be closely packed. The gravel may be cemented or not. On the slopes of the hill below the gravel layer, there are pebbles (a'') few or many, identical in character with those above. Unlike the gravel layer above however, these pebbles have no particular arrangement, and have the appearance of having rolled down the slope to their present position. Along with the loose pebbles there may be masses of conglomerate originating from the gravel above, in case the same is cemented. Beneath the gravel, there is a considerable body of sand (*b*), sometimes distinctly stratified and sometimes not. Seams or pockets of gravel (a') identical in character with that above, may occur in the sand, and occasional pebbles exist where no well defined seam can be traced. Laminæ of the sand at frequent intervals are indurated (b'), and bits of ferruginous sandstone derived therefrom, (b'') are freely mingled with the pebbles which have come down from higher levels. The pebbles and the sandstone fragments lie upon the eroded edges of the nearly horizontal layers of the sand and gravel stratum. Together with these talus materials there are often large numbers of iron-cemented sand-concretions (c'), identical in kind with those (c) which may be taken from the undisturbed beds of sand. Like the fragments of the sandstone, they originated close at hand, in the sand layers of the hill itself.

The erosion slopes of the hills, cut out of the horizontally though irregularly stratified sands and gravels, are thus seen to be strewn with gravel, sandstone debris, and ferruginous concretions, originating from the same series higher on the slope. Overspreading the whole, covering the crests of the

hills and the eroded edges of the sand and gravel layers, together with their thin covering of local debris, as above indicated, is the mantle of loess. It is absent only where recent erosion has been sufficient to effect its removal. How far the uniformity of distribution of loess over regions of strongly accentuated relief may be due to the creep of the plastic material down the slopes, is not here discussed; but this is not believed to be an adequate explanation of its uniform slope distribution. The loess and its clayey equivalents, are confidently believed to have been deposited like a mantle over a previously eroded surface. If the body of the hills be Paleozoic rock with only a capping of gravel and sand, the relation of the loess to the latter is not altered.

In view of this marked unconformity, it seems necessary to conclude that the deposition of the gravels and sands must have antedated a long period of pre-loessial erosion, since they themselves suffered erosion, and very extensive erosion, before the close of the first glacial epoch, when the main body of the loess appears to have been deposited. In many places there is evidence that cementation of the gravels and sands of the Orange Sand formation, had been accomplished before erosion had proceeded far. But since cementation may proceed rapidly, it does not seem necessary to allow for any notable interval of time, succeeding the deposition and preceding the erosion of the sands and gravel. Such interval must have been long enough, however, to allow for the shifting of attitude necessary to change the area of Orange Sand, from one of subaqueous deposition, to one of subaërial erosion.

The force of the above argument is not destroyed, although it may seem to be weakened, by the fact that the relationship between loess and Orange Sand here depicted, does not hold throughout the whole area of the development of the latter. Nowhere else, within the range of the writers' observation, is the unconformity so well shown as in southeastern Illinois. But similar facts are less strikingly exhibited at various points in southeastern Missouri, in western Kentucky, in Arkansas and Tennessee. That the degree of unconformity should vary is not strange, since the attitude of the land was such as to expose it to greater erosion on the flanks of the valley and the highlands of southern Illinois, than in the axis of the valley, where the approach to conformity is greatest. In the south the land appears to have remained so low as to allow of little or no erosion beween the Orange Sand and the loess.

From a second line of evidence it may be safely concluded that there was an interval of considerable duration between the deposition of the loess and the deposition and exposure of its substratum.

Although the lapse of time since the closing stages of the first glacial epoch is great, the loess does not appear to have undergone any considerable alteration in chemical character since the time of its deposition. Its surface portion for a depth of 4–6 feet, often shows unmistakable signs of oxidation and weathering. Locally, oxidation has penetrated to greater depths. The particles of the surface portion have been disintegrated by chemical and physical means, so that they have become notably finer than they were at the time of their deposition, and finer than those of the lower portions at the same locality. Were another sheet of loess to be spread over the first to-day, the distinction between the two in later times would be perfectly clear, on account of the chemical and physical changes which the present loess has suffered in its superficial parts. Yet even this distinction would be far less conspicuous than that which now exists between the loess and the surface of the underlying material. This comparison may be in some sense unfair, since it is true that the substratum of the loess and the loess itself are inherently dissimilar; but it is not that difference which is here insisted upon. It is the degree of alteration which the surface of the material below the loess has suffered—an alteration such as surface exposure would effect—which is of significance, and this alteration, which must have taken place before the deposition of the loess, is in general very much greater than that which the surface of the loess has undergone since the close of the first glacial epoch.

In many places there is a thin layer (4–8 feet) of earth above the gravels of the Orange Sand series. This is believed to represent, in many places at least, the last work of the waters which deposited the coarser materials below. It is commonly somewhat gritty, the gritty element (sand) partaking of the nature of the sand below, but it is distinctly clayey in texture. The textural difference between it and the loess is much less than that between the loess and the upper surface of the Orange Sands as commonly developed, but quite as great as that between the loess and the till. But it is in just such situations that the line marking the junction of the loess and the underlying earth is most conspicuous and significant. The latter shows the texture and deep coloration which denote the oxidation and surface alteration that result from long exposure to atmospheric action. In many places the junction of the loess with this layer, is the most obtrusive line in the section. In more than one place, it may be noted in passing, does this super-gravel earth show an eroded surface, upon which the loess rests unconformably, though the degree of unconformity in such cases is often slight.

The chemical changes in the sands and gravels are not confined to their surfaces. Beneath the surface, and so far beneath as to be below the zone of active surface weathering, there is evidence that great changes have taken place, denoting the lapse of long intervals of time. The most obvious of these changes is the extent to which the leaching and concentration of coloring matter has been carried. Besides this there are various other changes less clearly defined, but which in the aggregate give to the whole series below the loess an appearance of age which is unmistakable. The changes which the Orange Sands have undergone since their deposition, certainly appear to be several times as great as those which the loess has suffered since its deposition. And while this might not be a safe standard for chronological measurements, taken by itself, it has a strong corroborative significance, since it falls into correspondence with conclusions drawn from other lines of evidence.

Outside the drift region, the material underlying the loess is often residuary earth derived from Paleozoic rock, instead of from Orange Sand. So far as oxidation and the changes induced by exposure are concerned, the residuary earths of the Paleozoic rocks do not seem notably more affected than those of the Orange Sands. This is but an eye estimate, and may be erroneous quantitatively considered, though it is based on the observation of hundreds and thousands of sections. But in any case the fact of very profound affection of the pre-loessial surface by atmospheric agencies in pre-loessial times, is believed to be beyond dispute. And this is no isolated phenomenon. Generally speaking, it holds throughout the length and breadth of the extra-drift loess territory, within the limits of the writers' observation, and by report much beyond. On this point Professor Hilgard writes:* "The Orange Sand . . . . . as a rule contains nothing that is capable of further oxidation or solution by atmospheric agencies, unless it be silex. Such complete peroxidation and lixiviation, the effects of which have been largely extended into underlying formations, unquestionably indicates a long subaërial exposure, from which the northwestern stratified drift was in a great measure exempt." Dr. Loughridge† likewise recognizes the presence of "a bed more clayey and darker (than the loess) in color," between the loess and Orange Sand at Hickman, Ky., and "4 feet of the stiff darker loam" below the loess and above the gravel at Columbus, Kentucky. These "darker loams" represent the oxidized and

* This Journal, vol. iv, page 266, 1872. The same point is repeatedly insisted upon by Professor Hilgard in other articles in this Journal, and in his report on the Agriculture and Geology of Mississippi.

† Kentucky Geol. Surv., Jackson Purchase Region, F., 1888, page 78.

humus-stained material of the pre-loessial surface, as we interpret the phenomena, and are to be sharply discriminated from the loess, with which, except in the matter of position, they have nothing to do We fully concur with Professor Hilgard in his conclusion that this material " unquestionably indicates a long subaërial exposure," before the deposition of the loess. In a few localities where the pre-loessial surface does not appear to have suffered erosion, and where the loess therefore appears to be conformable with the substratum, the junction is marked by a humus-stained layer indicating an old soil. This occupies the same position, relatively, as the oxidized and weathered upper surface of the Orange Sands described above, and points to the same conclusion as to the sequence of events.

From the relative position of loess and Orange Sand, it is evident that the latter is the older. From the stratigraphic relations of the two formations, it is equally evident that the deposition of the former followed that of the latter, only after a considerable interval of time. The chemical changes which the older formation has suffered, strengthen the conclusion drawn from the unconformity, that the interval was long.

The main deposition of the loess seems to have taken place during the second episode of the first glacial epoch. The only evidence that we have thus far developed of a similar deposition that could be referred to the earlier episode of the first glacial epoch, is found in the lower stratum of loess, separated from the higher by the humus-marked and oxidized horizon, referred to above, as occurring at Memphis, Forrest City, and several other points on Crowley's Ridge. This lower subdivision of the loess, although fairly differentiated at these points, is not distinguishable at a sufficient number of points to make it certain that it is the fluvial representative of the first episode of the first glacial epoch.* If the force of the correlation of this lower division of the loess with the earliest drift be set aside, it might be supposed that the Orange Sands were synchronous with the first episode of this epoch. Were this their age, there would have been an interval between their deposition and the deposition of the loess. While this interval is not believed to have been long enough, or nearly long enough, to bring about the changes which the Orange Sand suffered before the loess epoch, our means of estimating time may be supposed to have led to erroneous conclusions, we therefore may seek the answer to the present question along another line.

* The observations recorded in the footnote on page 377, seem to make it reasonably certain that the lower subdivision of the loess here referred to, is the fluvial representative of the first episode of the first glacial epoch. This however does not weaken the argument here adduced, although it may seem to make it unnecessary.

Were the gravels and sands of the Orange Sand series to be referred to the first episode of the first glacial epoch, their origin should be revealed by their constitution, if glacial waters were the depositing agent. In this case we should confidently expect to find pebbles of northern origin among these gravels. It would not be necessary to suppose that all the gravel deposited by a stream springing from the glacier would necessarily be northern, since tributaries might bring in material from other directions, in the ordinary process of river degradation. But emphasize the importance of this latter consideration as we may, it yet remains an indisputable fact, that, were the conditions of drainage such that tributaries could bring gravel to their main in great quantities, the main itself, if springing from the ice, would inevitably bring something of glacial debris, which would be found mixed with the material of more local origin, brought in by the tributaries. And this would be true, even if the accumulation took place at an earlier stage of the glaciation of the first episode, long before the ice approached the latitudes under consideration; for the drainage basin of the Mississippi reaches several hundred miles to the northward, and probably extended still farther in that direction at an early stage of the ice invasion, when the ice had so far spread itself over the British possessions as to prevent drainage into Hudson's Bay.

If then, the Orange sands and gravels were accumulated during the first glaciation of the first glacial epoch, as valley or estuary deposits, we should of necessity have northern material represented in this formation, if not in the form of sands and gravels, *at least in the form of silt.* Such, however, is not the fact. In the hundreds of exposures of gravel which the writers have seen, large numbers of which, in various localities in six states, have been examined in detail for this especial purpose, not a single pebble of demonstrably northern or glacial origin has ever been found. Northern pebbles have been found associated with pebbles *derived from the gravels* under consideration, but only in such situations that the secondary character of the deposits containing such pebbles, was certain or altogether probable, from considerations entirely independent of those here adduced. And the freedom from glacial gravel and sand and silt does not characterize the Orange sands simply in their most southern distribution, where the local material might naturally be more abundant than to the north, but even up to the northern limit of the Orange Sand region, scarcely more than a score of miles from the southern border of the glacial drift, the northern or glacial materials are likewise altogether absent.

Even in the silts and loams that overlie the gravels and underlie the weathered and humus-marked horizon which divides the gravels, sands and silts below, from the loess above, microscopic examination fails to reveal the particles of the various complex silicates and dolomite which characterize the loess above, and which characterize all glacial silts with which we have any familiarity. It is to us wholly incredible that these sands and silts could have been deposited by a river originating in a glaciated tract, without including these characteristic products of the glacial grinding.

If it be suggested that the gravels date from the interval between the two glaciations of the first glacial epoch, and so from a time when the streams did not carry glacial waters, the case is no better. For on this hypothesis, even if the main stream did not carry glacial waters at the time of the deposition of the sands and gravels, it was still coursing through a basin covered with drift, and this drift must certainly have yielded its contributions to the river gravels, for by hypothesis the conditions of drainage were such as to allow the rivers to transport gravel and sand. The only escape from this conclusion would be to suppose that neither the Mississippi nor its tributaries north of the limit of drift, had power to transport sand and gravel, or even silt, and that both the Mississippi and its tributaries south of the drift limits, had such power. But it is incredible that there could have been drainage conditions up to within 25 miles of the edge of the ice, or up to within 25 miles of the drift sheet if the ice had retreated, such that enormous quantities of gravel could have been brought in by tributaries from right and left, and carried down by the Mississippi well toward the Gulf of Mexico, while the Mississippi just above the point where current velocities necessary to the above work existed, should be so sluggish as to bring down nothing whatever of glacial gravel or sand or silt from the north. If the main were strong enough to carry down the gravel of its extra-drift tributaries (and it certainly was, if the Orange gravel be river gravel at all, or if it ever were transported through the Mississippi valley), it would in all likelihood be strong enough to erode above these tributaries, and the material which it brought down from its intra-drift course, would be admixed when deposited, with that contributed by the extra-drift tributaries. If then the Orange gravels be river gravels, and if drift existed in the Mississippi basin when they were deposited, even if the ice had wholly retreated from the same so that no glacial waters coursed through the valley, such drift must certainly have yielded a contribution of gravel and sand to the Mississippi, both directly and through tributaries, at the same time that the tributaries south of the drift

limit were making their contribution of sand and gravel. In this case as in the other, there would necessarily be northern material in the gravel. The freedom of the Orange sands from all northern material, therefore, seems altogether conclu sive against the reference of its gravels to the time of the first glaciation, or to any time subsequent to the first glaciation.

We are not oblivious of statements concerning the constitution of the Orange sand and gravel, which are quite at variance with our own. By implication at least, all geologists who have referred them to the Champlain epoch, assign them a northern origin. Professor Hilgard thinks the difference between the Orange sand formation and the northern drift, "quantitative rather than qualitative," and that the materials of the two "are essentially correspondent,"* but we have been unable to find any basis in the regions we have studied, for such conclusions.

If the position of the Orange sands under first-glacial loess be fatal to their reference to the Champlain epoch, and if their unconformity with the loess, and their "perfect peroxidation" antecedent to the deposition of the loess, be fatal to their reference to an epoch immediately preceding that of the loess, no less does the complete absence of glacial material from the Orange sands and gravels, seem to us to preclude their reference to the ice period, or to any period subsequent to the first ice invasion. We are therefore shut up to the conclusion that the Orange sands are Pre-pleistocene. And even if an occasional northern Archæan pebble should hereafter be found in the Orange sand, we should not, on the strength of this evidence alone, regard our present conclusion invalidated; for the drainage basin of the Mississippi reaches well back into the area of Archæan rocks, and it would not be at all surprising if Archæan pebbles from this source should have found their way into the lower Mississippi Valley before the glacial period.†

It may be an open question whether the formation below the loess in the region under consideration, immediately preceded the Pleistocene, but it is not the purpose of this article to discuss that question. It is pertinent to the subject here discussed, however, to remark that the conditions of drainage during the first glacial epoch were such as to produce only exceedingly sluggish currents, so far as now known. But the Orange sands, whether of fluvial or estuarian deposition, date

* This Journal, vol. xli, pp. 313 and 315, 1866.

† Hilgard says (this Journal, xli, p. 318), that there have been found "rare and well worn pebbles of greenstone, porphyry, trappean rock, and even mica schist. . . . . among the shingle of the Mississippi band," and raises the question whether they may not have originated from Arkansas. Considering the absence of such material in the gravels of the Orange sand formation farther north, this hypothesis seems plausible.

from a time when drainage conditions were such as to allow the rivers to bring in large quantities of gravel, and often of very coarse gravel, from widely different sources. It is therefore manifest that the attitude of the country must have been very different in the Orange Sand and the glacial epochs, and the shifting of attitudes to match the drainage conditions of these two epochs, may have involved a considerable lapse of time.

In the light of the foregoing evidence, we find but one conclusion possible, respecting the age of the Orange Sand. In six states at least, it is true that beneath the loess and above the Orange Sand there is an old surface so deeply weathered and oxidized, as to indicate a long period of exposure before the deposition of the loess. Occasionally this old surface is humus-stained, indicating the growth of vegetation upon it, before the subsequent formation was made. Between this weathered and oxidized or humus-stained surface and the loess, there is wide-spread and often striking stratigraphic unconformity. Everywhere below this horizon, which is clearly recognizable in nearly every one of the thousands of exposures seen by the writers, there is an absence of material which can be referred to a glacial origin, while above this horizon, the loess and other fluvial deposits contain material of glacial derivation.* *This old surface, this horizon of oxidation, weathering and erosion; this horizon below which glacially derived materials do not occur, and above which they are present, we hold to be the dividing plane between the Pleistocene and the Pre-pleistocene formations.*

Thus far no mention has been made of certain beds of gravel which have given rise to more or less of misinterpretation. So soon as the gravels of the Orange Sand series were elevated above the waters which deposited them, their degradation began. From these Pre-pleistocene gravels, materials have been eroded and re-deposited throughout the course of Pleistocene time, and these processes of erosion and re-deposition are still in progress. That there are, therefore, beds of gravel derived from the Pre-pleistocene formation in Pleistocene times, goes with saying. Such of these beds as were formed in Pleistocene time previous to the deposition of the loess, might well contain glacial pebbles. Such of these beds as were formed during the epoch of the loess, and in the region where the loess was accumulating, necessarily contain something of the later material. In post-loessial times too,

* Microscopic study of these silts and earths cannot be said to have been carried to an exhaustive extent. But the statements here made seem to be fully warranted by the work already done.

loess and gravel have been carried down slopes and deposited together at their bases. But none of the gravel beds of this category belong to the Orange Sand formation, or to the formation of bluff gravels of Safford, and their existence has no bearing upon the conclusion cited above.

It remains to indicate briefly the relationship of the second glacial deposits to those of the first, in the region under consideration. Starting from the points where the edge of the ice sheet crossed them, trains of gravels stretch down the valleys which served as avenues of discharge for the glacial waters. From the terminal moraines of the second epoch in which they head, these gravel trains, in the form of valley plains, extend down the valleys for great distances. Into these plains, post-glacial streams have sunk themselves, and such portions of the plains as have escaped removal constitute the gravel terraces which are so generally found in the valleys heading within the area of second glacial drift, from the Atlantic to Dakota. From the position of these terraces in relation to the terminal moraines, there can be no doubt as to their second glacial age. Their constitution too, in comparison with that of the material of the same grade of coarseness in the adjacent second glacial till, confirms the conclusion to which their position leads. Traced down stream, these terraces decline, somewhat rapidly at first, but soon more slowly. There is also a change in their physical constitution as followed down the valleys. The coarse gravel issuing from the moraines soon gives place to finer, and this ultimately to sand. Often there is but a single terrace, representing the level of the glacial flood plain, but often also, there are terraces at lower levels, representing subsequent stages of post-glacial river degradation.

These terraces of the Mississippi Valley are of especial significance in this connection, since this valley traverses the region under consideration. Not only does the altitude of the main terrace above the sea decline southward from the moraine, but its elevation above the stream likewise diminishes in the same direction, until it disappears altogether below the present flood plain of the Mississippi.* We have not seen the terrace south of the limit of glacial drift in Illinois, though terrace remnants near the mouths of tributaries occur at about that latitude, and may exist still further down the valley.

In the Ohio Valley at Louisville, there is a corresponding terrace, built up of material brought down by tributary streams heading within the area covered by second glacial ice. This

* Below the point where second glacial terraces have been identified, there are, in places, low plains slightly above the present flood plain of the Mississippi, which possibly are to be correlated with these terraces.

terrace, if we correlate rightly, may be traced nearly to the junction of this valley with that of the Mississippi. The streams tributary to the Ohio from the north, have their systems of terraces corresponding to those of their main, and the streams tributary to the Mississippi—so far as they head within the area of second glacial drift—are likewise terrace-bordered. At various points in many of these valleys, the terraces have been removed by late erosion, so that the modern flood plain extends from bluff to bluff.

The Mississippi Valley south of the latitude where the terraces occur, is known to have a filling of considerable depth and of geologically recent age. This filling, as we interpret, is in large part of second glacial origin, is in fact the southward extension of the northern terraces, and constitutes the only southern representative of the second glacial epoch. We have never seen the material brought up by the borings in the Mississippi flat, but borings in the Ohio flat, not far from the Mississippi (Mound City, Ill.), show sand of unmistakably glacial origin. Here the filling is certainly second glacial. The inference that the corresponding filling of the Mississippi is of the same age, lies close at hand, quite apart from the argument drawn from the southward decline of the Mississippi terraces, and their disappearance beneath the flood plain.*

* Since this article was written, the junior author has revisited some of the localities referred to in the first paragraph of p. 364, and at a season especially favorable for observations bearing on the question here raised. The lack of homogeneity in the loess is much more conspicuously shown when the face of the section is wet, than when it is dry, and it was mostly in the latter condition that the loess sections of this region had been seen heretofore. The new observations seem to leave little doubt that the loess, outside the drift limit, is to be referred to two episodes of deposition. The loess sections just east of Forrest City, Ark., seem most conclusive. Here there are two loesses, separated by a thin belt of humus-stained soil. This soil constitutes a sharply marked horizon throughout considerable parts of the extensive railway cuts near the station. It is not everywhere equally conspicuous, apparently containing varying amounts of organic material; but well-defined or ill-defined, it is a very persistent feature of the Forrest City cuts. The loams above and below this soil are identified as loess by their mineralogical constitution, by their fossils and by their *kindchen*. The upper surface of the lower loess sometimes shows unmistakable signs of oxidation and weathering, just below the soil. Laboratory tests for organic matter sustain the determination made in the field, that the coloring matter of the old soil is of vegetable origin. At scores of points in Illinois, Kentucky, Tennessee, Arkansas and Missouri, a similar division of the loess occurs, as distinctly marked as in some parts of the Forrest City section, where the less clearly marked soil is traceable into direct continuity with that which is unmistakable.

The lower division of the extra-drift loess we refer to the first episode of the first glacial epoch.

Art. XLII.—*On certain Measures of the Intensity of Solar Radiation;* by William Ferrel.

Where one thing in nature increases or decreases with another, either from the relation of cause and effect, or any other, the first cannot be regarded as a true relative measure of the second, unless there is strict proportionality in the increase or decrease of the two. The height of the mercury in a thermometer with reference to temperature, and in a barometer with reference to air-pressure, very nearly fulfills this condition, but not accurately so, and it is well understood that certain corrections have to be applied to the heights of the mercurial columns in both cases before they can be regarded as true measures of temperature in the one case, or of air-pressure in the other.

The mere differences of temperature indicated by the black-bulb thermometer exposed in the open air to solar radiation, and the air-temperature, without regard to absolute temperature or the commotions of the air, were once used as true measures of the intensity of solar radiation. But it was soon discovered that the uncertain effects of air currents so changed the indications, that they were worthless as measures of this intensity. To obviate these effects the black-bulb was then placed in vacuo in a glass inclosure, and the differences between the temperatures of the black-bulb thermometer, and the air-temperature were regarded as true relative measures of the intensity of solar radiation, without regard to the absolute temperatures.

On account of the uncertainties of the air-temperatures, and the differences between them and those of the glass inclosure, an apparatus, called the *Arago-Davy actinometer*, consisting of a black and a bright-bulb thermometer in vacuo in glass inclosures, has been used, especially at the meteorological observatory at Montsouris, and the differences of temperatures indicated by the two thermometers, when exposed to the solar rays, without regard to absolute temperatures, have been used as true relation measures of the intensity of radiation.

It was first shown by the writer* that, in neither case, can the mere differences be regarded as true measures of the intensity of radiation; that not only are these differences not proportional to the intensity of the radiation for the same absolute temperatures, but that they differ very much for different temperatures, when the intensity of the radiation is the

* Temperature of the Atmosphere and the Earth's Surface, Professional Paper of the Signal Service, No. XIII; and Recent Advances in Meteorology; Report of the Chief Signal Officer for 1885, Part II, pp.375–380.

same, and formulæ were given for computing the true relative intensities from the observed absolute temperatures and their differences. Several other forms of apparatus of the same nature might be here named, used for the same purpose, and all affected similarly by the same cause of error. In all these instruments it is assumed, in accordance with what is called Newton's law, that the rate of radiation of any body, and so of its rate of cooling by radiation, is proportional to the differences of its temperature and that of the surroundings, whatever the absolute temperature may be, and so that these differences are true measures of the intensity of the radiation by which they are maintained. But this so-called law of Newton's was merely a first suggestion before experiments had been made to test its accuracy, and it is now known that it does not hold, with any degree of accuracy, through a range of 10° C. It is therefore remarkable that certain physicists, even in recent times, have extended this law up to the high temperature of the sun, and have thus obtained temperatures for that luminary, ranging from 10,000,000° C. down to much lower, but still very extraordinary temperatures, all based upon the assumption that Newton's law holds through so great ranges of temperature.

A modified form of the thermopile, called the *registering actinometer*, has been used for several years by M. A. Crova to determine the relative intensities of solar radiation. It is composed of two parallel disks, each one consisting of two metallic plates soldered together under pressure of $\frac{1}{50}$ of a millimeter in thickness and $0{\cdot}015^{m}$ in diameter, constituting a thermo-electric element fastened in a thin tube of brass; one of the junctions is in the dark, and the other receives a pencil of solar rays falling normally upon the blackened surface in the axis of the tube, which is provided with five diaphragms of aluminum of progressive decrease of opening down to the last, which is 4^{mm} in diameter. The opening of the tube is kept, by means of clock-work, accurately directed toward the sun during the day, and the amount of deflection of the galvanometer needle at any time, represented by a continuous curve of the registering apparatus, is taken as a true measure of the intensity of solar radiation. The following are some of the results obtained by this apparatus (Compt. Rend., ci, p. 418, August, 1885): "At sunrise the radiation increases with rapidity until nine or ten o'clock, an epoch at which it always attains its maximum, then it oscillates rapidly from one part to the other of its mean value, which diminishes on attaining a minimum at the time of greatest temperature, it then increases until about four o'clock without ever attaining the maximum

of nine hours, and then decreases regularly until the setting of the sun.

The smallest clouds and the least atmospheric disturbances are followed by oscillations of the curve. There is a great contrast between the apparent constancy of the light of the sun, and the continued oscillations of the curve, especially during a fair sky and calm weather."

Again the following deductions are made from the curves subsequently obtained after his first notice of the apparatus (Compt. Rend., cii, p. 962, April, 1886):

"1. The oscillations during the days of summer (with a very pure sky and without apparent clouds) are the more marked as the atmosphere is most calm and its temperature the highest; two maxima, the one before and the other after mid-day, are sufficiently distinct, the one from the other.

2. During the days of autumn the oscillations diminish in amplitude, and the maxima approach mid-day.

3. During the days of winter the oscillations persist, but their amplitudes still diminish more; the two maxima tend more and more to be confounded with each other.

4. In fine, during winter days, when the temperature is the lowest, and the mass of vapor contained in the air the least, the two maxima unite into one, which occurs at midday: with these conditions, especially if the atmosphere is strongly braced by violent winds, hourly curves are obtained almost entirely symmetrical with reference to the ordinate of mid-day."

Similar curves were subsequently obtained at places a long distance from the ocean, where the air was supposed to be much dryer than at Montpellier, where the first ones were obtained.

In this apparatus it is assumed that, for all temperatures, the intensities of the thermo-electric currents, indicated by the deflecting of the galvanometer needle, are proportional to the thermo-electric forces, that these are proportional to the differences of temperature between the two ends of the thermopile, and that these again, are proportional to the intensities of the solar radiation by which these differences are maintained, and so that the deflections of the galvanometer needle are proportional to the intensities of the radiation, and are consequently true relative measures of them. But none of these assumptions, it seems to the writer, is strictly correct.

By Ohm's law we have

$$I = \frac{E}{R} \qquad (1)$$

in which I is the intensity of the thermo-electric current, E is the thermo-electric force and R is the resistance. In this ex-

pression E and R are functions of the temperature; and such that, for not very great ranges of temperature, we can put

$$E=C(1+c\tau)\delta, \qquad R=R_\circ(1+r\tau). \tag{2}$$

In the first of these the temperature τ is to be taken for the mean of the range δ, the difference of temperature between the two ends of the thermopile, and C and c are constants. In the latter $R_\circ$ is the resistance at the temperature $\tau=0$, and r is a constant. With these values of E and R, we get

$$I=\frac{C(1+c\tau)}{R_\circ(1+r\tau)}\delta. \tag{3}$$

Hence I is not proportional to δ, except for a constant temperature, and for different temperatures there are different relations between I and δ.

Since δ is the change of temperature of the plate from being exposed to the sun's rays, and consequently the difference of temperature between the plate and the surroundings, its value, in a state of equilibrium or constancy, must be such, that the plate loses heat just as fast as it receives it from the sun. Now the loss of heat may be by radiation, conduction and convection, but is mostly by the former. The conduction of heat through the air becomes considerable, in comparison with the radiation of it, mostly in the case of curved surfaces only with small radii of curvature, as those of small thermometer bulbs and small wires, and is inconsiderable generally in the case of flat surfaces. But of course much depends upon the nearness of the surface to the surroundings receiving the heat; for the rate of radiation is independent of this. From the construction of the instrument there cannot be any sensible effect from convection currents, except perhaps from such as arise from the outside disturbances of the atmosphere in windy weather.

Considering here the effect of radiation only, we would have by the Newtonian law of radiation, the rate of losing heat by the plate, and so the intensity of solar radiation, proportional to δ for all temperatures and all ranges of δ, but this is not the case for any other law. By the law of Dulong & Petit, putting i for the intensity of solar radiation, we have

$$i=B\mu^\tau(\mu^\delta-1)=B\mu^\tau(\mu-1)\delta \tag{4}$$

in which $\mu=1{\cdot}0077$ and B is a constant depending upon extent of surface and radiativity, and τ is reckoned in degrees of the Centigrade scale. The value of δ from this expression in (4) gives

$$I=\frac{C(1+c\tau)}{R_\circ(1+r\tau)}\cdot\frac{i}{B(\mu-1)\mu^\tau}. \tag{5}$$

It is readily seen that the relation between I and i depends upon the temperature τ, and so is different for different temperatures, and consequently I cannot be regarded as a relative measure of i under all circumstances, but only when τ remains constant. For instance, the ratio between I and i is not the same when $\tau=0$, as in a summer temperature when $\tau=25°$.

If we put $I_\circ$ for the value of I when τ is equal to any assumed value $\tau_\circ$, and put

$$\Delta=\tau-\tau_\circ \tag{6}$$

we get from (5)

$$I_\circ=I\times\frac{1+c\tau_\circ}{1+c\tau}\cdot\frac{1+r\tau}{1+r\tau_\circ}\cdot\frac{\mu^\tau}{\mu^{\tau_\circ}}=I\times(1-c\Delta)(1+r\Delta)\mu^\Delta \tag{7}$$

in which the last form of expression is only approximate, but sufficiently accurate, unless Δ is large. Hence, in order to make the observed intensities I of the electric current measures of radiations it is necessary to reduce them to a common temperature $\tau_\circ$, which, in order to make Δ small, should be a medium temperature, or at least one not varying much from such a temperature.

With regard to the values of the constants c, r and μ, that of c differs with different metals forming the circuit, and may be either positive or negative. That of r is always positive, and differs but little in different metals. It was remarked by Clausius that the electrical resistance of all chemically pure metals should be proportional to the absolute temperature, and if so, we should have $r=·00366$. Experiment very nearly verifies this law, but mostly makes the increase of resistance in a ratio a little greater. We shall therefore put

$$r=0·0038 \tag{8}$$

The value of $\mu=1·0077$ given above was obtained from experiments made through a range from 80° to 240° C., but it has been shown by the writer* that for lower temperatures it must be much greater, the value at 50° C. being about 1·0088, and for still lower temperatures it should be considerably greater.

According to Stefan's law of radiation, we have

$$i=KT^{e-1}\delta \tag{9}$$

in which $e=4$, K is a constant, and T is the absolute temperature. The value of δ from this expression, substituted in (3), gives

$$I_\circ=\frac{C(1+c\tau)}{R_\circ(1+r\tau)}\cdot\frac{i}{KT^{e-1}} \tag{10}$$

* This Journal, vol. xxxviii, July, 1889.

From this we get, proceeding in the same manner as in the preceding case,

$$I_\circ = I \times \frac{1+c\tau_\circ}{1+c\tau} \cdot \frac{1+r\tau}{1+r\tau_\circ} \cdot \left(\frac{T}{T_\circ}\right)^{e-1} = I \times \left\{ 1 + \left(-c + r + \frac{e-1}{T_\circ} \right) \Delta \right\} \quad (11)$$

the latter form of expression being sufficiently accurate where $\Delta = \tau - \tau_\circ$ is not very large.

From this expression it is seen that the observed electric intensities, indicated by the deflections of the galvanometer needle, must be multiplied into a factor which is a function of Δ and $T_\circ$, in order to reduce them to $I_\circ$, the intensities which would have been observed if the apparatus had remained at the same temperature $\tau_\circ$, or corresponding absolute temperature $T_\circ$. The two metals used in the thermoelectric circuit of Crova's apparatus are unknown to the writer, but we will suppose, for the sake of illustration, that they are iron and copper. In this case we should have $c = -\cdot00366$. The value of $e=4$ of Stefan's law has been shown by the writer, in the paper already referred to, to be too large for ordinary air temperatures, and he has given the following formula for computing its value for any given temperature τ:

$$e = 3 + \cdot00032\,\tau + \cdot00032 \frac{T \log T}{M} \quad (12)$$

in which M is the modulus of common logarithms. For $\tau = 15°$, this gives $e = 3\cdot53$ very nearly, but the value varies very little throughout the usual range of working temperatures. With these values of c and e, and that of r in (8), we get from (11), with $T_\circ = 272 + 15 = 288°$,

$$I_\circ = I \times (1 + (\cdot00366 + \cdot0038 + \cdot0088)\Delta) = I \times (1 + \cdot01526\Delta) \quad (13)$$

In this expression if we assume the temperature $\tau_\circ$ in (6) from which Δ is reckoned to be that of 10 o'clock. Then the values of Δ for the hours preceding that hour would be negative, and after that hour positive, in all ordinary cases of fair weather, and hence the observed values of I would be decreased before 10 o'clock and increased after that hour, and it is readily seen that this would tend to throw the maximum at least toward midday, and to fill up the observed depression in the afternoon. It does not appear adequate, however, to render the forenoon and afternoon curves symmetrical, and at least a considerable part of the effect which destroys this symmetry is undoubtedly to be attributed to the different hygrometric conditions of the air in the forenoon and afternoon. But both effects are in the same direction and have the same epochs of maxima and minima, so that there is no way of separating them and determining how much belongs to each. But even

with the correction given by the preceding formula the lack of symmetry between the forenoon and afternoon branch of the curve is greater than that in such curves generally from other means of measuring the intensities, though these are generally, though not always, less in the afternoon than in the forenoon.

It is perhaps doubtful whether Crova's curves, rightly interpreted, would really give as much depression in the afternoon as is inferred. From 10 o'clock on, through most of the afternoon, the oscillations of the curve about the medium line are very great, and such a line seems to have a great depression, and even a second maximum; but as the lowest points of the curve represent only the exceptionable states of the atmosphere, which are perhaps of comparatively short duration, the curve representing the average intensities would have to be drawn higher up, nearer to the upper extremes of the oscillations. These oscillations, also indicated by the bolometer, are undoubtedly caused by what may be called invisible clouds, the atmosphere during the warmer part of the day being in an unstable state, in which local ascending currents are formed and the vapor contained in them, in cooling, does not quite arrive at the state of saturation and condensation; or if so, the condensation is not quite sufficient to cause a visible cloud at great altitudes, as is frequently the case when numerous small patches of cumulus cloud are formed.

It is evident from an inspection of (11), that the observed values of I in summer and in winter, or in low latitudes and high latitudes, or low and high altitudes, or in any circumstances in which there is a difference of temperature, are not comparable without a reduction to the same temperature. For instance, using (13) instead of the first expression, though not very accurate for large values $\Delta=\tau-\tau_0$, and supposing Δ to be equal to 20°, we get $I_0=1{\cdot}305\ I$, so that the observed value at the temperature τ, must be increased nearly one-third to make it comparable with one observed at the temperature τ_0, according to the formula above. But it is not to be understood here that this formula, with the numerical constants used, is claimed to be a correct reduction, but simply one which gives roughly the order of reduction which may be required, and it is given rather as an illustration merely, than as a correct formula of reduction, even in the case in which iron and copper are used in the thermoelectric circuit. For other metals, of course, the formula would be different. Some allowance, also, must be made for the effects of neglected conduction and convection.

In the *bolometer* the deflection of the galvanometer needle is proportional to the differences of temperature of the bolometer strips, and so the first two factors into which I in (11) is multiplied disappear. But there are the same relations between

these very small temperature differences and the corresponding intensities of radiation which produce them, as in the case of the exposed plate in the registering actinometer; so that the higher the temperature, the greater the amount of solar or other radiation required to raise the temperature of the strips a given very small amount, which we have denoted by δ. By the law of Dulong and Petit the relation between i and δ for any given temperature τ is given by (4), but by Stefan's law it is given by (9). Proceeding as before, except neglecting the terms containing c and r as factors, we get, with the relation of Stefan's law, instead of (11),

$$I_o = I \times \left(\frac{T}{T_o}\right)^{e-1} = I \times \left(1 + \frac{e-1}{T_o} \Delta\right) \qquad (14)$$

the latter form being only approximate and not very accurate where Δ is large. It is seen, therefore, that the observed intensities I, in order to be comparable, must be multiplied into a factor which is a function of the temperature in order to reduce them to what they would have been with an absolute temperature equal to T_o. Or, if we wish to reduce the observed value of I_o at temperature T_o to that of I at temperature T, we must divide by this factor.

From Langley's Researches on Solar Heat, Tables 108 and 110, p. 136, we get the following average values of the sums of all the deflections of the several wave-lengths, namely: for Lone Pine 710, and for Mountain Camp 1284, using only the observations of September 2 and 3 in the latter. These are the uncorrected deflections, to which large corrections have to be applied, especially to those of the shorter wave-lengths, but the corrected results must give nearly the same ratio between Lone Pine and Mountain Camp. Langley found from actinometer observations that the intensities of solar radiation at Mountain Camp were about one-ninth greater than at Lone Pine. Increasing, therefore, 710 by one-ninth, we get 789 for what the sum of the deflections at Mountain Camp should have been, if they are proportional to the intensities of the radiation below and above, instead of 1284. Now this is much too great a difference to be all due to difference of temperature, according to the formula of (14). Temperature observations at Lone Pine and Mountain Camp, which are required for an application of the formula, are not given, except in one case it is stated that the temperature of the galvanometer at Lone Pine was 97° F. But from observations of wet- and dry-bulb thermometers about the same time for hygrometric purposes, it may be inferred that the differences of temperature between Lone Pine and Mountain Camp could scarcely have been as much as 20° C. Using this for the value of Δ in (14), and

$T_o = 286°$, which was about the absolute temperature at Mountain Camp, and $e = 3{\cdot}53$, as previously determined, we get $I_o = 1{\cdot}185\ I$, that is, by the formula, the intensities at Mountain Camp should be increased over those made at Lone Pine at a higher temperature and then reduced for difference of level to Mountain Camp, in the ratio of $1 : 1{\cdot}185$. But we have seen that the bolometer observations make this in the ratio of $789 : 1284$ or $1 : 1{\cdot}63$. Observations, therefore, indicate that in the case of both the registering actinometer and the bolometer, a reduction for difference of temperature is required, but what is perplexing in the matter is, that the reduction required, especially in the case of the bolometer, is much greater than that given by the preceding formulæ of reduction.

It is not to be understood that this is a matter which affects any of Langley's results, for he used the bolometer to determine the relative intensities only of the several different wavelengths, which were all made at the same times for each series, and consequently at the same temperatures.

In what precedes, the writer wishes to state in conclusion, that he has ventured with considerable timidity upon unfamiliar ground, and that it is possible he may have made some blunders. If so, it will be matter for discussion and correction.

Martinsburg, W. Va., Jan. 7.

ART. XLIII.—*Geological Age of the Saganaga Syenite;* by HORACE V. WINCHELL, F.G.S.A.

THE Saganaga Syenite is an area of syenitic and granitic rocks occupying largely the shores and islands of the lake called by the Ojibways *Kasaganaga* (the lake with many islands or the lake surrounded by thick forests, as differently interpreted), which lake is situated on the international boundary line between Minnesota and Ontario, and has many long arms extending north and south from the line. This syenite is also found around Sea Gull lake, and occupies an area of about 100 square miles in the State of Minnesota, in townships 65 and 66 north, ranges 4 and 5 west of the fourth principal meridian. The hills surrounding these lakes rise to a height varying from 100 to 300 feet, and consist of bare glaciated knobs of syenite. These hills are apparently the northeastern prolongation of the Giants' Range, a mountainous range of syenitic rock extending in a general northeast direction from the Mississippi River to the Canadian boundary line.

The general composition and structure of the syenite have been fully described in the Sixteenth Annual Report of the

Minnesota Geological Survey, pp. 211–233. The prominent macroscopic characters are described as follows: "wherever the Saganaga syenite is traced large grains of quartz constitute a distinctive character. These grains are large, angular and numerous, and on weathered surfaces stand out prominently. The feldspar exists in subangular patches, imbedded with the quartz in a ground mass which is mostly chloritic, and in places develops chlorite spots, while in other places hornblende forms emerge into visibility. So, apparently, a syenite appears or disappears. These characters I have learned to recognize as the borderland between schistic and gneissic areas."* Again, considerable quartz is mentioned as occurring in this rock in some parts of the region. On page 215 of the same report, we find it stated that white quartz is seen in considerable abundance, some being in veins one or two inches in diameter, but mostly resulting from the excessive abundance of the usual quartz grains. These are said to be "very unevenly disseminated through the syenite, sometimes aggregated, and in places nearly wanting. The rock itself is not of course a characteristic syenite. All hornblende has disappeared. A feldspathic matrix remains, with some green specks and spots, and the quartz is imbedded in it; some of the broken surfaces of the rock have a sericitic luster. The formation on the whole appears roughly bedded with a dip of 63°." The general strike is N. 70° E. The syenite of Saganaga lake is also found to be conglomeritic in places, and contains pebbles which are strikingly similar to each other in composition and appearance. They are said to be "quite uniform in lithological aspect. They are uniformly dark colored, and in a rough way would be called greenstones." If it were not for the difference in color between the so-called pebbles and the matrix in which they are imbedded, we should be inclined to consider this as an agglomerate similar to those so numerous in the Keewatin and so characteristic of it. A majority of the "pebbles" are composed of lamellar augite with or without apparent small grains of feldspar. There are no pebbles of syenite or jasper and no sedimentary fragments.

The significance of the facts mentioned above will become apparent in the course of this paper. Before educing any conclusions from them however, it is desirable to mention a few further observations made by the writer in the latter part of October, 1890. The observation of greatest importance and which it is believed has never before been made in this region, was the discovery of a band of chalcedonic silica, one and one-half inches in diameter, and about three feet in length in the

* A. Winchell, 16 Minn. Rep., p. 214.

syenite of the Saganaga region. This phenomenon may be seen at the end of a portage on Granite river, which forms the international boundary line between Gunflint and Saganaga lakes. This band of silica is perfectly straight and so clearly exposed that it is surprising that it has not been noticed before. It has an east and west direction corresponding to the general strike of the rocks in this region, and to the observed foliation and coarse-bedded structure sometimes noticed in the syenite. It stands vertically in the pink crystalline rock, and has along one side a streak of greenish chloritic matter only a fraction of an inch in thickness.

The significance of this ribbon of chalcedonic silica in crystalline syenite may be more clearly perceived if we consider the nature and origin of this particular kind of silica as elucidated from the rocks of Keewatin age, and studied for several years in northern Minnesota. The method of formation of this peculiar variety of quartz has been outlined in a paper entitled: "On a possible Chemical origin of the Iron Ores of the Keewatin in Minnesota," by N. H. Winchell and H. V. Winchell, read Sept. 2, 1889 at the Toronto meeting of the A.A.A.S., and has been treated in all fullness of detail as to structure, chemical and petrographical characters in a forthcoming bulletin of the Minnesota Geological Survey on the Iron Ores of Minnesota. In the article and bulletin referred to it is shown that this quartz, which forms the siliceous part of the jaspilyte associated with the iron ore deposits, is amorphous and non-crystalline. It is associated directly with rocks of igneo-aqueous origin, and was formed by chemical precipitation from heated oceanic waters at a very early stage of the world's history. It mingles with the volcanic ashes and lavas of the Keewatin in amounts varying from a fraction of a per cent to almost absolutely chemically pure silica. It is a striking and unique characteristic of the rocks of the Keewatin age, and has only to be seen to be recognized even in such peculiar associations as in the Saganaga syenite. Wherever found it indicates solution and oceanic deposition.

Leaving chalcedonic silica for a moment, let us consider another set of facts noticed in the Saganaga syenite area. On the north side of Saganaga lake in Ontario, the rock composing the shore is found to consist largely of greenish feldspathic and sericitic schists and agglomerates. The syenite passes into these earthy schists directly, without the usual intervening schists of the Vermilion age. So frequent and so varied are the changes from syenite or chloritic syenite gneiss into thick bedded or almost massive ridges of Keewatin rock that the conclusion is inevitable that they are not separate formations, but that the metamorphism of the schists has been more in-

tense in certain belts of country, and the syenite is simply the result of this intensity. This phenomenon of locally intensified metamorphism may be easily accounted for if we remember that pressure alone cannot develop heat, but pressure together with motion produces intense heat at the planes where the motion takes place.* Thus if the Keewatin strata at Saganaga were folded at an early period, so as to stand up vertical, the lateral pressure would not effect one portion of the rocks more than another. But if this lateral pressure were accompanied by a slipping of some ridges up and of others down, the result would be ridges slightly altered alternating with highly metamorphosed Keewatin strata. For a space of several miles along the north side of the lake this condition of affairs is noticeable. The ridges of Keewatin green schist, and of syenitic rock rise in bare alternating or intermingling ranges of varying width and altitude, but generally of such narrow width, that there are half a dozen such transitions in the space of a quarter of a mile. At a short distance it is impossible to say whether the rock ahead is more like Keewatin green schist and agglomerate, or the syenite peculiar to the southern half of the lake. The agglomeritic structure is almost universal in the hills a short distance north of the lake shore, and suggests again the idea that the wonderful syenite conglomerate may be only a Keewatin agglomerate highly altered locally. This is not at all unreasonable, for the bowlder forms in the green schist are neither so much altered structurally by the assorting agency of the ocean in which they fell as volcanic bombs, nor so acidic by reason of the intermingled chalcedonic silica as the surrounding rock, and hence would remain as green "pebbles" under metamorphism sufficiently intense to convert the matrix into syenite.

The presence of chalcedonic silica in the Saganaga syenite together with the structural relations existing between the non-crystalline Keewatin schists, and the crystalline syenite supposed to be of Laurentian age amount almost to conclusive proof that the materials of which the syenite is composed are not Laurentian but Keewatin in age. The presence of the numerous and large quartz grains mentioned above as being characteristic of the syenite of the Giant's Range may now be easily explained when we consider the immense amount of chemically deposited chalcedonic silica in the Keewatin. The same metamorphism, which by hydro-thermal fusion and pressure formed the orthoclase and hornblende from the other ingredients has been sufficient to crystallize most of the silica into large grains.

* O. Fisher, Physics of the Earth's Crust, 1889, p. 2.

That this metamorphism was of very early date, we are confident because the syenite is found to underlie unconformably the quartzites and slates of the Taconic or Huronian. The change from non-crystalline to crystalline was probably produced at the time of the folding of the earth's crust which turned both the Keewatin green schist and the Keewatin syenite up on edge so that they stand vertical over a large part of northern Minnesota.

If the Saganaga syenite be as supposed, the northeastern extension of the Giant's Range, then this whole belt of rock from the Mississippi river to the Canadian boundary and beyond must be Keewatin and not Laurentian. And indeed there are indications from the relations of the Giant's Range syenite to the vertical green schists on the south of the syenite as seen near Hinsdale on the Duluth & Iron Range R. R., that this is a correct inference. If this extensive range of gneissic rock which has generally been supposed to be Laurentian is then not truly Laurentian but Keewatin, it seems likely that in the latter we have a rock come down to us unchanged through all the ages, which in its various phases represents the original fire crust of the earth more nearly than any other known rock. But this is a question to be discussed at some future time.

In closing, I wish to suggest an economic bearing of this question. If the Saganaga syenite be of Keewatin age, and contain chalcedonic silica in an original unchanged condition, it is not unlikely to contain also Keewatin iron ore deposits free from titanium, and of high grade in other respects. It can thus no longer be laid down as a law for explorers in the northwest that the gneisses contain no iron ore deposits. It is believed that the non-titaniferous magnetites of New York and eastern Canada afford good illustrations of this class of iron ores, and that they have been changed from chemically precipitated hematites of Keewatin age.

December 20th, 1890.

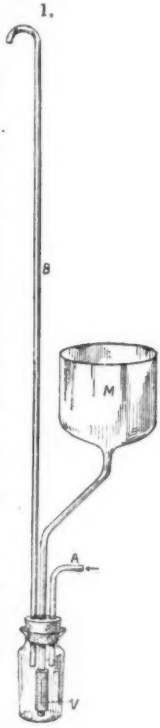
Art. XLIV.—*On a Self-feeding Sprengel Pump;* by H. L. Wells.

The arrangement here described for raising mercury continuously to the top of a Sprengel pump, or for other purposes, may be of use or of interest to some chemists and physicists. The method, though exceedingly simple, seems to be new.

Fig. 1 shows the apparatus in its simplest form. Water

under pressure is admitted at A, it flows into the small bottle, then up through the tube B. On the tube of M, in the bottle, is a valve V which allows a liquid to flow into the bottle, but closes when the pressure is in the opposite direction. Now if mercury is placed in the reservoir M it will flow down into the bottle, provided the column of mercury more than counterbalances the column of water in B and the pressure caused by the friction of the current passing through it The conditions just mentioned are easily attained by making the mercury column about one-fifth or one-fourth the height of the water column and regulating the flow of water so that the friction is not very great. Under these circumstances the mercury rises in the tube B to a height somewhat less than its level in M, the valve then closes, and, if the bore of this tube is not too great, the mercury which has risen in it must be carried up to the top by the current of water. As soon as this mercury is forced out at the top of B, the valve opens again and the whole operation is repeated.

1.



This apparatus, which may be called a mercury elevator, must be seen in operation to be fully appreciated. It works rapidly and with great efficiency, and the automatic action of the valve makes it an interesting piece of physical apparatus.

Two forms of valves have been used with good success. The well-known Bunsen valve is shown at V in fig. 1. For this purpose it should be made of a quite heavy rubber tube so that it will not collapse under the pressure. Another form of valve is shown in fig. 2, which is perhaps somewhat preferable since it cannot collapse under the pressure, and if properly constructed it delivers mercury more promptly than the other. It is made by grinding a rather thin-walled glass tube on a grindstone until a narrow opening is made as shown in *b;* a soft, rather thin rubber tube, fitting the glass tube snugly, is cut as shown in *a*, somewhat less than half the section of the tube being cut away. The rubber tube is then drawn over the glass tube so that the openings are on opposite sides. Whichever valve is used, care must be taken to have it large

2.

enough to deliver mercury rapidly, for otherwise the efficiency of the apparatus will suffer.

3.

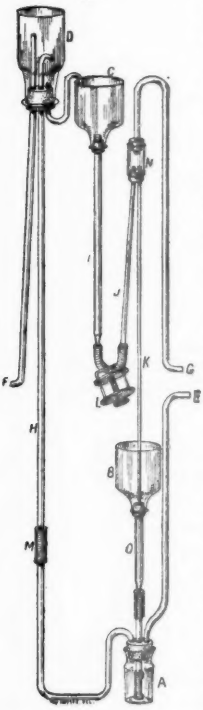


Fig. 3 represents a Sprengel pump, with the mercury elevator, now in use in this laboratory. The artist has relatively shortened most of the tubes, and has exaggerated some parts of the apparatus for the sake of clearness of detail.

The whole apparatus can be easily constructed with the materials usually at hand in a chemical laboratory. Water enters at E, carries mercury up through H and overflows through F, while the mercury goes through a trap into the reservoir C of the Sprengel pump.

The total height of the apparatus is 2400^{mm}. The bore of the tubes E, H and F is 5–6^{mm}. The tube H, where it leaves the bottle A, takes a downward curve, thus increasing the length of the intermittent column of mercury raised. The inverted siphon* formed by the tubes I and J prevents air, water or sulphuric acid, which may be in C, from being carried over into the pump proper, no matter how slowly mercury may be delivered. I has a bore of 8–10^{mm} and is 900^{mm} long; J is 850^{mm} long with a bore of 3½^{mm}.

The Sprengel tube K is about 1500^{mm} long with a bore of 3^{mm}. It is very important for the sake of rapid pumping, that this "fall-tube" should be long and have a bore as large as consistent with good working.† If this tube is larger at one end than the other, as it may be advantageously, the smaller end should be uppermost, because it is at the top, if anywhere, that mercury fails to fill the bore of the tube, and also because this form of tube prevents the atmospheric pressure from forcing a column of mercury upwards out of it, since the column lengthens when it rises.

* A Sprengel pump with this modification is described and figured in Sutton's "Volumetric Analysis," edition of 1871, p. 262.

† The proper caliber of the fall-tube is given by Sprengel (Jour. Chem. Soc., 1865, p. 15) as 2½^{mm}. He says that with larger tubes his vacuua were ½–1^{mm} less than the barometric height, hence where the most perfect exhaustion was required it would be advisable to use a tube of the size which he gives. Sprengel limited the length of his fall-tube by the height at which it was convenient to pour back the mercury into the reservoir at the top, but it is evident that much longer fall-tubes could be used conveniently with the "mercury elevator."

The tube N* is about 50^{mm} long, and 12^{mm} in diameter, and is surrounded by a larger tube, not shown in the figure, which is closed at both ends with rubber stoppers and filled with concentrated glycerine.† This glycerine may be replaced by mercury where moisture in the exhausted space is to be carefully guarded against.

The tube G, with which the vessel to be exhausted is connected, is of rather heavy glass with a small bore. The highest point of its curve at the top should be above any possible level of mercury in the reservoir C. The tube O has a bore of 8–10^{mm} so that it may readily fill with mercury, while its prolongation, to which the valve is attached, has a bore of about 6^{mm}. The height of B above A determines the amount of mercury raised by a given stream of water. In the present apparatus this height is 500^{mm}, and it is sufficient to work the pump rapidly, but where a sufficient water-pressure was available, it would perhaps be better to increase this to 600^{mm} or more, with a corresponding addition to the height of the whole apparatus. It is evident that the height of this reservoir above the valve-bottle should be considerably less than the column of mercury which the head of water at disposal will raise by direct pressure. This water-pressure, in the case of an apparatus of the dimensions just described, is less than necessary to run an ordinary water-jet pump at its best efficiency; in fact, this apparatus was devised in order to overcome the difficulties, due to varying water-pressure in this laboratory, which were experienced with the water-pump in distilling under diminished pressure, and it may be mentioned that the apparatus has been very successful for this purpose. The bottle A should be as small in diameter as convenient for making the attachments, and its stopper should be securely wired down before putting on the pressure.

The support to which the apparatus is attached is an upright board 300^{mm} wide with a base about 600^{mm} square. The reservoirs B, C and D are securely set into the board in such positions that the various tubes rest against its surface.

To start the action of the apparatus a slow stream of water is first started through it, then mercury is poured in at B. A trial will determine approximately the best speed at which to run the water.

When the use of the pump is to be discontinued the clamp L is first closed and the excess of mercury, which need be only a small quantity, is allowed to be carried up into C before

* A connection of this kind for a Sprengel pump is described by Johnson and Jenkins, Am. Chem. Jour., vol. ii., p. 29.

† A joint surrounded by glycerine for this purpose is described by Frankland and Armstrong, Jour. Chem. Soc., 1868, p. 91.

stopping the water-current. If, at starting, the excess of mercury remaining in A and the tubes connected with it is so great that the water-pressure cannot lift it out of the tube H, it will be necessary to disconnect the rubber tube M and force out the excess of mercury at this point by means of the usual stream of water.

The mercury delivered into the Sprengel-tube may carry traces of water with it, particularly when there is water in the reservoir C and when, at the same time, mercury is allowed to run through the pump faster than the elevator is raising it, so that the mercury-level sinks to a low point in the tube I. In this case water-vapor can be guarded against by placing concentrated sulphuric acid in C.

Sheffield Laboratory, New Haven, Conn., March, 1891.

ART. XLV.—*Contributions to Mineralogy, No. 50;* by F. A. GENTH; *with Crystallographic Notes* by S. L. PENFIELD and L. V. PIRSSON.

1. On Three New Varieties of Axinite.

a. Axinite from Franklin, New Jersey.

THE specimens for examination were received from Messrs. Geo. L. English & Co. The axinite, both, in crystals and laminated masses, is found, as a great rarity, associated with a beautiful rose-colored variety of fowlerite, polyadelphite, biotite and barite. The crystals are of a beautiful honey-yellow or pale greenish yellow color, from about 1^{mm} to 5^{mm} in size. Spec. grav. of the crystals = 3·358, of the laminated masses = 3·306.

The axinite crystals are of interest as they have a very unusual habit and also possess some rare planes.

The forms which have been observed are as follows, using Naumann's position.

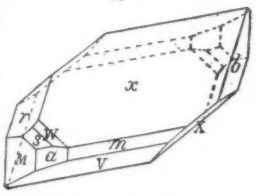
a, 100, i-$\bar{i}$	*m*, 110, *I*	*x*, 111, $-1'$	*s*, 201, -2-$\bar{i}$	*X*, $0\bar{2}1$, 2-$\bar{i}$
b, 010, i-$\bar{i}$	*M*, $1\bar{1}0$, *I*	*r*, $1\bar{1}1$, -1	*W*, 312, $-\frac{3}{2}$-3′	*V*, $\bar{1}\bar{1}2$, $\frac{1}{2}$

As seen in figure 1 the crystals are tabular from an unusual development of the *x* faces, giving a habit unlike anything which the authors are familiar with in this species. The face *W*, 312, is well developed and is new. It was readily determined by measurement and its occurrence in the zone *M s x*. *V*, $\bar{1}\bar{1}2$, is a rare form which is not given by Goldschmidt* or Frazier† in their lists of axinite planes. It is

* Index der Krystallformen. † This Journal, III, xxiv, p. 439.

however mentioned by Schrauf, as the pyramid μ, 131, of his position, and shown on a crystal from Miask, Ural, in figure 16 of his Atlas. X is also a rare plane observed by vom Rath* in crystals from Botallack, Cornwall. It is the brachypinacoid b of vom Rath and Schrauf. The two rare planes V and X are very prominent on the Franklin crystals as seen in the figure. All the faces have a fine luster and gave good reflections of the signal on the goniometer. The planes in the zone M, s, W, x are striated parallel to their mutual intersections and the measurements in this zone were therefore not so exact as the others. Some of the important measured and calculated angles are as follows, using the following elements, $\breve{a} : \bar{b} : \dot{c} = 0{\cdot}49211 : 1 : 0{\cdot}47970$:

1.



$a = 82° 54' 13''$ $\beta = 91° 51' 43''$ $\gamma = 131° 32' 19''$

		Measured.	Calculated.			Measured.	Calculated.
$x \wedge r$,	$111 \wedge 1\bar{1}1 =$	40° 48′	40° 46′	$m \wedge a$,	$110 \wedge 100 =$	15° 25′	15° 34′
$r \wedge b$,	$1\bar{1}1 \wedge 0\bar{1}0 =$	93° 22′	93° 21′	$a \wedge M$,	$100 \wedge 1\bar{1}0 =$	28° 8′	28° 55′
$r \wedge X$,	$1\bar{1}1 \wedge 0\bar{2}1 =$	68° 24′	68° 24′	$m \wedge V$,	$\bar{1}10 \wedge \bar{1}\bar{1}2 =$	45° 8′	45° 11′
$r \wedge m'$,	$1\bar{1}1 \wedge \bar{1}\bar{1}0 =$	115° 37′	115° 38′	$x \wedge s$,	$111 \wedge 201 =$	16° 5′	16° 7′
$m \wedge s$,	$110 \wedge 201 =$	27° 51′	27° 57′	$x \wedge M$,	$111 \wedge 1\bar{1}0 =$	48° 46′	48° 25′
$b \wedge m$,	$010 \wedge 110 =$	32° 48′	32° 47′	$x \wedge W$,	$111 \wedge 312 =$	9° 8′	9° 22′

All of the above measurements were made on one crystal about 2^{mm} in its greatest diameter.

The material for the analyses was dried over sulphuric acid; the boric acid was determined by Gooch's method by distillation with methyl alcohol. The following results were obtained:

	Crystals.	Laminated.	
	1.	2.	3.
Ignition ... =	0·76	0·40	0·41
SiO_2	42·77	42·47	42·28
B_2O_3	5·10	5·05	not det.
Al_2O_3	16·73	16·85	16·88
Fe_2O_3	1·03	1·16	1·36
PbO	----	0·09	----
CuO	0·12	0·11	1·57
ZnO	1·48	1·53	
MnO	13·69	13·14	12·97
MgO	0·23	0·26	0·17
CaO	18·25	18·35	19·54
	100·16	99·41	

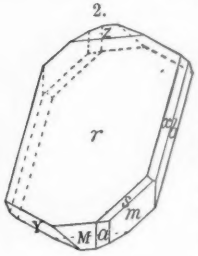
As might be expected from this locality the mineral contains a higher percentage of manganese than has ever been observed before as well as some zinc.

* Pogg. Ann., cviii, p. 243.

b. Axinite from Guadalcazar, Mexico.

The material for examination was kindly presented by Messrs. Geo. L. English & Co. The axinite is associated with a white feldspar, in part altered to kaolinite; it is found in minute crystals, the largest not over 5^{mm} in size, and granular scaly masses, the individual scales from $1–2^{mm}$. The color is brownish to greenish gray of various shades (sage color). Spec. grav. =3·299.

2.



These crystals are tabular parallel to the pyramid r, $1\bar{1}1$, fig. 2. The faces are usually curved and uneven and some of them are striated, a and m parallel to their intersection and r parallel to the zone $M\,r$, so that the crystals are not suited for exact measurement on the goniometer. The following forms were identified by measurements, which seldom varied more than half a degree from the calculated.

a, 100, i-$\bar{i}$	*m*, 110, I'	*r*, $1\bar{1}1$, -1	*z*, $1\bar{1}2$, $-\frac{1}{2}$
b, 010, i-i	*M*, $1\bar{1}0$, I	*x*, 111, $-1'$	*Y*, $\bar{1}31$, $3\text{-}\frac{3}{2}'$
c, 001, O	*s*, 201, $-2\text{-}\bar{i}$	*e*, $\bar{1}11$, $1'$	*n*, $1\bar{3}1$, $-3\text{-}\frac{3}{2}$

Of these c, e and n, not represented in the figure, on most of the crystals are either wanting or very small: s and x are small and frequently wanting: the other forms are quite constant, about as represented in the figure.

The larger crystals did not yield very good material for analysis as they are often too intimately mixed with feldspar; the granular variety however was in places almost pure, containing only traces of kaolinite from which it was easily purified.

The analysis gave:

Ignition	= 0·75
SiO_2	42·85
B_2O_3	5·17
Al_2O_3	16·96
Fe_2O_3	5·00
CuO	0·19
MnO	9·59
MgO	0·87
CaO	18·49
	99·87

There were two minute crystals associated with this axinite, one of white color in pyramids, apparently quadratic; the other black, neither of which could be identified.

c. Axinite, from McKay's Brook, which empties into the N. E. Mirimichi River, Northumberland Co., N. S.

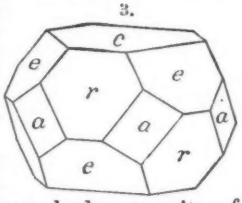
Only one small fragment of about 15×10^{mm} in size, received from Mr. Samuel Hufty in Camden, N. J., consists of very small brown and brownish gray tabular crystals, arranged to form a somewhat columnar granular rock. The crystals are too imperfect for satisfactory measurements, a qualitative chemical examination proves the mineral to be axinite.

2. On Eudialyte from Magnet Cove, Ark.

The material for this and the following mineral was also kindly furnished by Messrs. Geo. L. English & Co.

The following observations on the eudialyte from Magnet Cove had been made when we received the article on eudialyte and eucolite from Magnet Cove, by J. Francis Williams, in the December number of this Journal, 1890. The crystals agree in every respect with the description given by Williams. Only the simple forms *c*, 0001, *O*; *r*, $10\bar{1}1$, 1; *e*, $01\bar{1}2$, $-\frac{1}{2}$ and *a*, $11\bar{2}0$, *i*-2, were observed. These were developed as shown in fig. 3. One crystal about $2\frac{1}{2}^{mm}$ in diameter was measured in which the mean of six independent measurements of $c \wedge e = 50° 44'$, and five of $c \wedge r = 67° 35'$. Williams calculates for these 50° 43′ and 67° 45½′ respectively, using $a : \dot{c} = 1 : 2{\cdot}1174$.

3.



The analyses from a want of crystallized material had to be made with the massive rose-colored of lighter and deeper shades, scarcity of either prevented making separate analyses of each; examination under a strong lens showed no impurity. Sp. gr.=2·810.

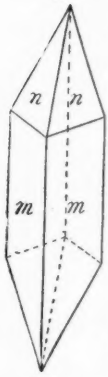
The analyses gave:

		1.	2.
Ignition	=	1·88	1·84
Cl		1·42	1·41
SiO_2		51·83	51·68
ZrO_2		11·45	11·62
Ta_2O_5 (?)		0·39	0·29
FeO		4·37	4·35
MnO		0·37	0·30
MgO		0·11	0·07
CaO		14·77	15·05
Na_2O		13·29	----
K_2O		0·43	----
		100·31	

The material for these analyses was not as good as desirable. It was obtained from the massive variety, occurring in rounded

particles, the largest of about 10mm diameter, disseminated through a mixture of feldspar and zeolites, and associated with ægirite, astrophyllite, titanite, etc. On account of its scarcity, the material, though selected with care and apparently free from admixtures, was not of uniform color, some particles being of a deep rose color, while others were of a much paler shade. It is not impossible that the latter have already suffered a partial alteration.

4.



3. On Titanite from Magnet Cove, Ark.

One of the rarer minerals of Magnet Cove is titanite. It occurs, associated with ægirite, orthoclase (or microcline) elaeolite, one or two zeolites, eudialyte and others in small pale brownish yellow or brown crystals. Sp. gr.=3·457.

The crystals are very simple and show a combination of the two forms *m*, 110, I and *n*, 111,−1, as in figure 4. The faces gave very poor reflections, so that only approximate measurements could be made.

The analysis gave:

Ignition	=	0·57
SiO_2		30·84
TiO_2		39·35
FeO		0·73
MgO		trace
CaO		28·26
		99·75

4. *Monticellite.*

Among the specimens from Magnet Cove, Ark., sent to me for identification by Messrs. Geo. L. English & Co., I observed the very rare species Monticellite. It is found in crystals and crystalline grains in a coarse-grained calcite, the individual grains of which are from 2 to 15mm in diameter, and is associated with small crystals of magnetite, rarely over 3mm in size and apatite, in microscopic colorless hexagonal prisms, but generally in crystalline radiating masses sometimes over 10mm in diameter. Mr. L. V. Pirsson has very kindly examined the crystals and gives in the following the results of his observations:

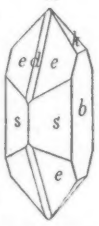
The crystals are not well adapted for accurate measurement, the faces being roughened in some places and in others lacking the polish on the crystal planes. A few faces gave moderately good reflections and on others by using the δ ocular of Websky, enough light could be condensed to give in a number of cases,

a fair image of the signal. These yielded moderately good measurements. Others however are only approximate from a "schimmer" measurement. The forms observed on two crystals which were measured are:

b,	010	$\bar{i}$-$\bar{i}$	*k*,	021	2-$\bar{i}$
s,	120	$\bar{i}$-2	*d*,	101	1-$\bar{i}$
m,	110	I	*e*,	111	1

The brachypinacoid is quite largely developed and also the brachydome 2-$\bar{i}$, and in these respects the crystals differ from those of the European localities. The habit is that of a short prism with pyramidal terminations as will be seen by reference to the figure. This crystal whose figure is given is about 3 ctm. in height, nearly 2 ctm. in breadth, parallel to the brachy-axis and a little more than 1 ctm. wide.

5.



The other crystal is characterized by the presence of the unit prism, in other respects it is quite similar to the one figured. The following table of calculated, and measured angles is appended to show the identification of the forms. For calculating the theoretical angles the axial ratios of vom Rath* have been taken, the lengths of the vertical and brachy-axes as given by him being halved, to bring them in accord with those of the chrysolite group, to which the mineral belongs.

These ratios are then,

$$a : b : c :: 0{\cdot}433689 : 1 : 0{\cdot}57569,$$

and for the calculated and measured angles we have:

		Calc.	Meas.
$b \wedge k$,	$010 \wedge 021$	40° 58½′	41° 11′
$b \wedge e$,	$010 \wedge 111$	70° 53½′	70° 50′
$s \wedge s$.	$120 \wedge 1\bar{2}0$	81° 52′	82° 07′
$s \wedge e$,	$120 \wedge 111$	38° 19′	38° 19′, 38° 22′
$b \wedge s$,	$010 \wedge 120$	49° 04′	48° 30′
$e \wedge d$,	$111 \wedge 101$	19° 06½′	19° 08′, 19° 08′
$m \wedge m$	$110 \wedge 1\bar{1}0$	46° 53½′	47° 01′

Fracture conchoidal to splintery, brittle; H.=5. Sp. gr.= 3·108. From colorless to brownish white and light brown. Luster vitreous on the fracture, inclining to greasy on the crystal planes. Readily soluble in dilute acids, both before and after ignition. In a preliminary analysis in which the cleanest crystal fragments were examined, it was found that they contained some water, silica, ferrous oxide, manganous oxide, magnesia and lime, but were *entirely free* from phosphoric acid. As such fragments could not be obtained entirely free from calcite, a quantity of the calcite, enclosing monticellite, was crushed

* Pogg. Ann., 1871, Erg. Bd., v, 434.

fine enough to pass through a sieve of about fifty meshes to the inch, and separated by Thoulet's solution; afterwards the magnetite was taken out by a magnet and the resulting material, apparently pure, was analyzed. To my great surprise considerable quantities of phosphoric acid were found which was present as apatite, which by a closer microscopic examination of the original specimens could easily be distinguished.

The analyses gave:

		1.	2.
Ignition	=	2·28	2·29
SiO_2		33·47	33·46
Al_2O_3		0·16	0·19
MnO		1·11	1·13
FeO		5·09	4·93
MgO		20·71	20·52
CaO		35·18	35·31
P_2O_5		1·98	2·08
		99·98	99·91

Deducting the phosphoric acid as $Ca_5F(PO_4)_3$ (fluorapatite) in the first analysis 4·57 per cent, in the second 4·82 per cent of the same, gives the following as the composition of the pure Arkansas Monticellite:

		1.	Mol. ratio.		2.	Mol. ratio.	
Ignition	=	2·39	·133		2·41	·133	
SiO_2		35·08	·585		35·19	·586	
$Al_{23}O$		0·17	---		0·20	---	
MnO		1·16	·016		1·19	·016	
FeO		5·33	·074	·633	5·18	·072	·628
MgO		21·71	·543		21·58	·540	
CaO		34·16	·610		34·25	·611	
		100·00			100·00		

Leaving out the water, the molecular ratios of SiO_2 : (Mg,Mn, Fe)O : CaO are:

in 1, ·585 : ·633 : ·610
in 2, ·586 : ·628 : ·611

corresponding to $(Mg,Mn,Fe)_2SiO_4 . Ca_2SiO_4$.

In both analyses the SiO_2 is a little short. As there is no sign of alteration and no lack of basic oxides, it is difficult to account for the presence of over 2 per cent of water, as the finely powdered mineral had been kept over sulphuric acid for several days before analyzing.

Chemical Laboratory, 111 S. 10th St., Philadelphia, Feb. 1, 1891.

Art. XLVI.—*Contributions to Mineralogy, No. 51;* by F. A. Genth.

1. *Aguilarite*, a new species.

A precious lot of about half a dozen specimens, secured by Mr. William Niven of Geo. L. English & Co, from Señor Aguilar, the superintendent of the San Carlos Mine at Guanajuato, Mexico, as Naumannite, were placed in my hands for identification. They all proved to be a new species which has been named *Aguilarite*, in acknowledgment to the discoverer of this interesting mineral. I am indebted to Messrs. Geo. L. English & Co. for allowing me to break off a sufficient quantity of this valuable material for investigation.

There was only *one piece* in the lot which gave aguilarite in a state of perfect purity. It is, associated with little quartz, imbedded in colorless calcite which was readily removed by dilute acetic acid. The pure crystals, thus obtained, were placed in the hands of Prof. S. L. Penfield, who very kindly determined the crystallization, of which he gives the following description:

"It is isometric; the crystals are skeleton dodecahedrons with only the edges well developed. Many are lengthened out in the direction of one of the crystallographic axes, looking then like a tetragonal prism, terminated by a pyramid of the opposite order; others are elongated in the direction of an octahedral axis and these resemble hexagonal prisms, terminated by a rhombohedron. I detached one crystal for measurement; it gave only approximate reflections; eight dodecahedral angles, in three different zones, gave angles which varied between 60° 33′ and 59° 35′, the average being 60° 5′, calculated 60° 0′. I also measured two angles over the top of the dodecahedron 89° 59′ and 90° 11′, calculated 90° 0′. The crystals are attached and grouped together, so that distinct, fully developed dodecahedrons do not seem to occur."

The largest crystals were not over $10^{mm} \times 6^{mm}$ in size, groups of crystals up to 15^{mm}. No cleavage observed; fracture hackly; sectile; malleable; H. = 2·5; sp. gr. = 7·586; color iron black; luster very brilliant. In an open tube at low heat, gradually increased to red heat, it yields metallic silver, a slight sublimate of selenium, slender silky needles of selenous oxide and sulphuric oxide, which latter, attacking silver, forms a small quantity of Ag_2SO_4; no SeO_2 could be observed. The analyses gave:

	1.	2.	Ratio.		Calculated.
Ag	79·13	79·07	·732	4	79·50
S	----	5·86	·183	1	5·89
Se	----	14·82	·188	1	14·61
		99·75			100·00

Represented by the formula : $Ag_2S + Ag_2Se$.

All the other specimens were more or less altered; the aguilarite crystals had become rounded, and in the proportion to the extent of the alteration, their crystalline form was more or less obliterated. They often were penetrated by round holes, showed the presence of metallic silver and were coated with microscopic iron-black crystals, sometimes in, apparently, hexagonal scales. Although this coating was quite brittle, I did not succeed in obtaining the unaltered nucleus of aguilarite in a state of purity, as has been proved by the following analyses :

	1.	2.	3.
Ag	78·09	77·85	75·75
S	not det.	7·55	8·32
Se	12·39	12·22	not det.

Sb, As, Cu, etc., not determined.

I was able to separate, in a state of approximate purity, a little over half a gram of the scaly brittle iron-black product of alteration, which gave :

		Ratio.			
Ag	67·08	·621		5·84	11·6
Cu	6·44	·101		0·94	2
Fe	0·82				
Sb	10·82	·090	·107	1·00	2
As	1·29	·017			
S	13·62	·426		3·98	8
	100·07				

Giving the molecular ratio of a cupriferous stephanite $5(Ag, Cu)_2S + (Sb, As)_2S_3$ with an admixture of metallic silver.

2. *Seleniferous Bismuthinite and Guanajuatite.*

A. *Seleniferous Bismuthinite.*—As crystallized Guanajuatite, Messrs. Geo. L. English & Co. sent me for identification a small specimen, consisting of slender, striated crystals, about 5^{mm} in length and 0·5 to 1^{mm} in thickness with distinct brachydiagonal cleavage, imbedded in indurated clay. Color light gray, some crystals showing a yellowish tarnish. Sp. gr. = 6·306. The analysis gave :

	1.	2.	Mean.	Ratio.		Calculated.
Bi...	76·94	78·14	77·54	·371	10	77·08
S....	14·15	13·96	14·06	·440	12	14·18
Se...	8·80	not det.	8·80	·111	3	8·74
	99·89		100·40			100·00

This would prove the mineral to be a seleniferous bismuthinite of the composition $4Bi_2S_3+Bi_2Se_3$. A piece which I received about four years ago from Prof. Carlos F. de Landero of Guadalajara, Mex., more compact, but with slender crystals, imbedded in indurated clay, looks as if it had come from the same mass which furnished Messrs. Geo. L. English & Co.'s specimen.

B. *Guanajuatite or Frenzelite.*—The results under "A" suggested repeating the analysis of Guanajuatite with a specimen which came from an old German collection, purchased about ten years ago. It is compact, granular, indistinctly fibrous and of a light gray color. Spec. grav. = 6·977. The results of the analysis are as follows:

		Ratio.		Calculated.		Frenzel found.
Bi....	68·86	·330	6	68·74	Bi ...	67·38
S.....	4·68	·146	3	5·27	S.....	6·60
S	25·50	·320	6	25·99	Se....	24·13
	99·04			100·00		

Corresponding to: $Bi_2S_3+2Bi_2Se_3$, analogous to the usual variety of tetradymite. The percentage of sulphur, in Frenzel's analysis, seems to be too high; as it is, the analysis would not lead to a rational formula, but the results are close enough to admit of a comparison with mine and suggest that the same mineral has been analyzed by both of us, and that the existence of the species cannot be questioned.

Chemical Laboratory, No. 111 S. 10th St., Philadelphia, March 23d, 1891.

Art. XLVII.—*Columbite of the Black Hills, South Dakota;* by Wm. P. Blake.

The publication of the paper on the columbite and tantalite of the Black Hills, of South Dakota, by Mr. W. P. Headden* is timely and important, particularly in giving for the first time a series of careful analyses of the mineral from the Etta Mine and from the Bob Ingersoll Claim, in comparison with

* This Journal, xli, 89, 1891.

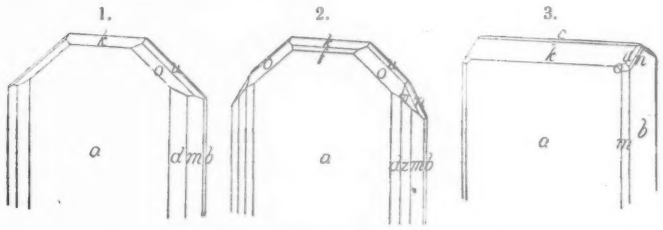
the composition of the species from other localities. It is also agreeable to find that my original determination as columbite of the mineral from both the Etta and the Ingersoll was correct.*

The specimens collected in 1884 have been carefully preserved with the intention of preparing a full description for publication so soon as the chemical investigation could be completed. As Mr. Headden's numerous analyses supply this want, it is now necessary only to present a few further notes and the results of a crystallographic study of the specimens, made at my request by Prof. S. L. Penfield, of the Sheffield Scientific School, and reported to me in April, 1890.

In breaking up the huge mass of columbite at the Ingersoll the only good crystalline terminations were those broken out from the quartz matrix. The mass when discovered by me did not show any crystallization which could have been used for the determination of its form. The exposed portions were rounded and weather worn. The blast which was intended to throw it out whole, if possible, disclosed the fact that it was made up largely of a series of broad plates interleaved in part by a translucent quartz. These plates are crystals flattened parallel to the macropinacoid a, 100, $i\text{-}\bar{\imath}$; some of them with bright crystal faces on the edges. The forms which were identified are as follows:

b, 010, $i\text{-}\breve{\imath}$	z, 530, $i\text{-}\frac{5}{3}$	k, 103, $\frac{1}{3}\text{-}\bar{\imath}$	o, 111, 1	π, 121, 2-$\breve{2}$
m, 110, I	d, 730, $i\text{-}\frac{7}{3}$	f, 102, $\frac{1}{2}\text{-}\bar{\imath}$	u, 133, 1-$\breve{3}$	n, 163, 2-$\breve{6}$

Fig. 1 represents the ordinary habit of the crystals while fig. 2 represents a more highly modified one which was observed. One small crystal had bright faces and gave on



the goniometer fair reflections of the signal. Some of the principal measurements for the identification of the faces are given below, and for comparison the calculated angles obtained from the axial relation established by E. S. Dana,†

$\breve{a} : \breve{b} : \dot{c} = 0{\cdot}8285 : 1 : 0{\cdot}88976$

* This Journal, xxviii, 340, 1884. † Zeitschr. Kryst., xii, p. 266, 1886.

	Measured.	Calculated.
$m \wedge d$, $110 \wedge 730$	20° 6′	20° 5½′
$m \wedge z$, $100 \wedge 530$	13 27	13 12½
$m \wedge m$, $110 \wedge \bar{1}10$	100 39	100 43
$a \wedge f$, $100 \wedge 102$	61 42	61 46
$a \wedge k$, $100 \wedge 103$	70 30	70 18
$a \wedge o$, $100 \wedge 111$	51 18	51 15½
$a \wedge u$, $100 \wedge 133$	74 52	75 1½
$a \wedge n$, $100 \wedge 163$	79 24	80 3
$a \wedge \pi$, $100 \wedge 121$	62 14	62 15

The prism *d*, which is prominent on these crystals, is new to the species.

The crystals from the Etta Mine are to a great extent independently formed and are thicker and stouter than those from the Ingersoll. The largest crystal secured weighs several pounds, and measures about 1½ inch by 5 inches and is 4¼ inches long; another is 1½×3×3½; and a fragment of a larger crystal is 2 inches thick and 4 inches long. Most of them are detached from the gangue, or matrix, but one has portions of beryl and quartz adhering to the side.

The habit of the crystals is dependent upon a prominent development of the pinacoids *a*, 100, $\dot{\imath}$-$\bar{\imath}$ and *b*, 010, $\dot{\imath}$-$\dot{\imath}$ and the macrodome *k*, 103, ⅓-$\bar{\imath}$. Other faces which were observed are *c*, 001, *O*; *m*, 110, *I*; *o*, 111, 1; *u*, 133, 1-$\check{3}$ and *n*, 163, 2-$\check{6}$. The arrangement of the planes is shown in fig. 3. The crystals were not suitable for accurate measurement; on the large crystals the forms were identified by means of a contact goniometer, and on a small crystal the following angles were measured on a reflecting goniometer:

	Measured.	Calculated.
$a \wedge k$, $100 \wedge 103$	70°	70° 18′
$a \wedge m$, $100 \wedge 110$	39 28′	39 38½
$a \wedge o$, $100 \wedge 111$	51 20	51 15½
$b \wedge n$, $010 \wedge 163$	29 15	30 50
$b \wedge u$, $010 \wedge 133$	49 15	50 3

The specific gravity determinations invariably show that the Etta variety is the heavier of the two. The results upon different crystals and fragments were as follows:

From the Etta Mine.		From the Ingersoll Claim.	
6·580	6·642	5·873	5·881
6·610	(6·447 Penfield.)	5·879	(5·901 Penfield.)

A small tabular crystal found loose in the soil of Etta Hill gave me 6·171 and another from Spring Creek 6·132. Mr. Headden's determinations of the specific gravity of the Etta specimens range from 5·890 to 6·750, and for the Ingersoll specimen he found 5·901.

ART. XLVIII.—*The Raised Reefs of Fernando de Noronha;* by HENRY N. RIDLEY, M.A., F.L.S., Director of Gardens and Forests, Straits Settlements.

I HAVE recently received three numbers of this Journal (for February, March and April, 1889) in which are papers by Messrs. Branner and Williams on the Petrology and Mineralogy of Fernando de Noronha. I was one of the party sent out by the Royal Society of England and the British Museum, to explore this island not only mineralogically but botanically and zoologically in 1887. My companions were the Rev. T. S. Lea and Mr. G. Ramage. We explored the whole group and brought home upwards of 200 specimens of rocks and minerals, with sketches, plans and photographs of the more interesting geological bits. The minerals, which are now in the British Museum, were worked out by Mr. Davies of that establishment, and a short account was published in the Journal of the Linnean Society (Botanical Division) as an introduction to the natural history. These are, though much condensed as the Linnean Society does not as a rule publish petrographical papers, our views upon the structure and history of Fernando de Noronha, from its petrology. I hope Mr. Davies will publish further notes upon our rock-specimens, at fuller length. The results we arrived at as to the origin and history of the island differ a good deal from those of Messrs. Branner and Williams especially as to the relations of the phonolite and basalt and the rocks included by the latter under the name of æolian sandstones. It is about the latter I should like to speak as we carefully examined this rock in all parts of the islands and brought home specimens in all states of existence.

Briefly stated our theory was that this certainly rather variable rock, is what we have called reef rock, and is the same rock that is forming at different spots along the shores of Fernando de Noronha, of the Recife at Pernambuco and at Itamaraca in the same province.

This reef rock is full of corals, nullipores, broken shells, tests of echini, and at low water mark it is full of living organisms. Break into the interior it is more and more compact the nearer you go towards the shore, and eventually and at no great distance within the mass, you will see that the forms of its constituent animals are gone, and the whole is an amorphous mass of carbonate of lime, not as I shall show later, pure but mixed with mud in varying quantities. Owing to its irregular structure and growth it is soon worn into those curious shaped pinnacles and peaks that one sees often buried

in the guano of Ilha Rapta. In fact in many places one can easily trace the reef rock into these so-called æolian sandstone.

Mr. Branner (l. c. April, 1890, p. 249) gives the analysis of a piece of this rock which contains 92·27 per cent. of carbonate of lime, and only 2·20 p. c. silica. Again, on page 256, he gives two analyses, one of a piece of sandstone from Ilha Rapta, a clean and compact piece of one of the "tall jagged points left by the etching out of the surface by the combined action of rain water and ocean spray." This which would naturally have lost more of its soluble calcium carbonate than silica gives 98·33 per cent. calcium carbonate and ·09 per cent of silica and other matter insoluble in concentrated nitric acid! Can one call this sandstone at all?

I may here mention I have just returned from a short visit to Christmas island in the South Atlantic; an oceanic island, south of Java and in many points recalling Fernando de Noronha. It has a high ridge rising very straight out of very deep water, I am told there is a volcanic backbone to the island, and I found pebbles of tuffs and traps on the shore, but had no time to reach it. There are no sandy bays or dunes as in Fernando de Noronha. Here and there a little bay a few yards across has coral sand in it; but the whole of the island is covered with rock exactly like that of Ilha Rapta. Here and there are cliffs, layer over layer laid straight down, of this rock, just as at Fernando de Noronha. What force could have hurled sand dunes from an abysmal depth to the top of the lofty hill of Christmas island and where did the sand come from? Comminuted shells, coral dust, etc., form the softer bottom in many of these places, but sand is not plentiful, if it occurs at all.

But there are true æolian sandstones in Fernando de Noronha, on São José we found a block of real sandstone; nearly pure silica, apparently made of drift sand and very hard and compact. It contained a pseudomorph of a large crystal of feldspar in quartz and two or three shells (marine) well preserved. We were a little doubtful as to the position of this rock, as it was in the fort and might have been imported. But at Bahia San Antonio there were large sand dunes and æolian sandstone forming. In most spots it was feebly held together, in some more compact. The sand was being agglutinated by carbonate of lime, true, but whence was this carbonate of lime? of corals, nullipores, sea-shells? Certainly not. It was derived from innumerable shells of Helices and Bulimi. There was, except a stray shell here and there dropped by a sea bird, not a marine organism, giving up its carbonate of lime to form the sandstone. This true æolian sandstone was

very different in appearance and constituents from the reef-rock. I noted some points with respect to the reef-rocks. This rock is not at all like the coral reef of the open ocean atoll, such as Cocos island. It is not built to any large extent of the larger corals, but the nullipore seaweeds take the most important part, broken shells, echinus tests, worm tubes, crabs all go to make it up. The growth is chiefly produced by the nullipores. Now the reef does not occur everywhere. It cannot grow on sand because of the fluctuation of the bottom nor on bowlders which are too irregular and constantly shifting. In every spot, where I noticed reef in Fernando de Noronha, I found a small stream trickling into the sea, bringing down silt enough to make a firm bottom for the nullipores. The same observation was made at the Recife (I prefer to keep the old name for the reef itself) and at Itamaraca. And even here I see that where streams debouch into the sea the silty banks they form on one side are the best places for corals. This fact would account for not only all the silica which is deposited in the "reef rock," but for in some cases a larger proportion. If Mr. Branner will examine the Pernambuco Recife at low tide, he will see how compact it is and how it rings to the hammer. It contains much silt, but it is not an æolian sandstone, but true reef rock still growing. If he will walk along the coast to Olinda he will pass plenty of sand banks but though these have probably been growing for centuries there is not a bit of the rock which he classes as æolian sandstone, simply because no silt comes down, and the sand is too shifting for any growth of nullipores, etc.

I noticed too that where the base of the supposed sandstone could be seen it always overlay, neither sand, nor bowlders but silt. One spot at first puzzled me. It is in Ilha Rapta at the landing place, here is a stratum of black basalt bowlders which at one part is covered with about ten feet of reef rock. At first sight the reef appeared in contact with the bowlders, but closer examination showed that the bowlders had been cemented together (with gypsum probably) and then covered with silty stuff on which the reef had grown.

Both at Fernando de Noronha and at Christmas Island raised reefs occurred in strata lying flat upon each other. In some spots the upper part of each reef seemed distinct in texture and coloring, suggesting a frame before the deposit of the next reef upon it. I do not see how sand dunes could be formed into flat regular strata like this. When I was recently at Anjar point in Java opposite Krakatao I was shown an immense block of stone said to have been thrown there from the volcano. On close examination, however, it proved to be a block of coral-limestone, a block of reef rock, just like those

of Christmas Island, and Fernando de Noronha, in which one could hardly descry any definite remnants of its constituent animals. It had probably been hurled upon the shore by the frightful wave which at the eruption of Krakatao struck this coast with such violence and destroyed so many people. I shall as opportunity occurs examine the growth of reef-rock in these seas, but in conclusion I must say that I cannot at all see in Mr. Branner's paper enough evidence to support the theory that these rocks are æolian sandstones, while it appears to me certain that they are nothing more nor less than raised reefs of different ages.

NOTE.—Mr. Branner is quite correct in calling attention to the names given to various portions of the island by English and French travellers, which names are quite unknown to the natives. The map published by the Geographical Society from our plan contains most of those really known to the inhabitants. One or two spots which were absolutely unnamed we gave English names to. As to Ilha Rapta as I have called it in this paper in deference to Mr. Branner, all the inhabitants assured us that it was Ilha dos Rattos (i. e., Rattos pequenos), but it is likely enough it was originally called Ilha Rapta and the name was altered since.

ART. XLIX.—*The Cause of Active Compressive Stress in Rocks and Recent Rock Flexures;* by T. MELLARD READE, C.E., F.G.S., etc.

I HAVE read with much interest the account of a recent rock flexure on the lower Fox River about six miles northeast of Appleton, Wis., by Mr. Frank Cramer.* The rocks appear to have been in a state of stress from lateral pressure beyond anything that could possibly be due to gravitation and irregularity of the ground. This stress may have been and probably has been accumulating for a great length of time, the excavation described giving the needed release or in other words acting as the trigger that set off the gun.

If the effect of the small anticlinal ridge thrown up had not been to crack the walls of the paper mill and dislocate the machinery, the probability is that the movement would have gone unnoticed and it is most likely that such small readjustments of the earth's crust take place with greater frequency than is suspected. There is, however, one surface phenomenon which will tend to minimize accumulation of lateral pressure

* This Journal, March, 1890, pp. 220–225.

and that is the greater development of jointing in the surface rocks. Joints are widened by atmospheric agencies so that the surface rocks are frequently cut up into blocks not in actual contact. This is very noticeable in the sandstone quarries in Darley Dale, Derbyshire, where the joints are sometimes filled with infiltrated bowlder clay.

It is evident that if the surface rocks are not continuous over a considerable area the throwing up of the anticlinal ridge could not take place because there could be no accumulation of lateral stress.

There is no doubt that alternations of temperature take place in deep seated rocks, causing their bulk to undergo considerable variation. These rocks, owing to the pressure they are subjected to, are in absolute contact and form a homogeneous mass. I have attempted to show (Origin of Mountain Ranges, Chap. XXV), that the sudden release of these accumulated stresses, whether of tension or compression in deep seated rocks, is the cause of earthquakes that happen away from volcanic centers, and also that earthquakes are more frequent and greater in intensity in areas occupied by the newer rocks such as the Tertiary in all parts of the globe. It is in these areas that the greatest underground fluctuations of temperature occur in the crust of the earth. While my work was going through the press, the earthquake that ravaged Georgia and South Carolina, known as the Charleston earthquake, occurred on the night of August 31, 1886, thus emphasizing in an unfortunate way the principles I had expounded. The substratum here is of Tertiary rocks and the area was not recognized as one of great seismic activity. On the contrary an eminent geologist had only just before been insisting upon the great stability of the Atlantic borders of the North American continent.

These changes of temperature cannot, however, excepting in a secondary manner affect surface rocks, for they are kept by atmospheric influences at the mean temperature of the station at which they occur; we may therefore dismiss change of temperature of the surface rocks themselves as a *vera causa*.

The uplift on the Lower Fox River, though a striking example, can be paralleled by other instances of lateral pressure in surface rocks disclosed in the process of quarrying, suggesting a similar release of accumulated stress by unloading. Professor Kenny Hughes gives an instance (Geol. Mag., 1887, p. 511) of the bursting up of the floor of a limestone quarry at Dent Head and also of the floor of a tunnel at Ribble Head in Yorkshire, but he attributes these, whether rightly or not I am unable to say, to the fact that the beds rest on shale, inferring that the unequal pressure caused by the removal of part of the rock

forced up the shale as a viscous mass and so breaking the limestone bed above it.

It is evident, however, that this explanation will not meet the cases mentioned by Professor W. H. Niles where the phenomenon of lateral pressure he describes have acted over a considerable area and under diverse conditions of rock structure.*

At Monson, Mass., the quarry was in a belt of gneiss lying east of the red sandstone of the Connecticut Valley. The strike of the gneiss is north 10° east and the dip 10° north at the high angle of 80°. The pressure as seen by the movements of the beds in the quarry appears to have been parallel to the strike or at right angles to the movement that originally flexed the beds.

At Berea, Ohio, the quarries in which movement was observed are in sandstone (Berea grit of the Waverley group), lying nearly horizontal and the movement was in a north and south line.

At Lemont, Illinois, the quarries were in the Niagara limestone and an anticlinal axis was formed striking east and west 800 feet in length and rising from 6 to 8 inches in the most conspicuous parts. "It was formed along the line of vertical joint which extends beyond the limits of the quarry. The continuous edges of the bed were bent upward, making an elevation which was a little more upon the north side of the joint than upon the south and a slight fault was in this way produced." Another quarry referred to is at Waterford, Conn., in gneiss, and another quoted from Professor Johnston is in sandstone at Portland, Conn. Professor J. Johnston† says that these sandstone quarries are of great extent and 120 feet deep from the original surface of the ground. A groove about a foot wide and 80 feet long was being cut in a bed about 6 or 7 feet thick and in an east and west direction parallel to a natural joint. When the channel had been sunk to within about 9 inches of the bottom of the strata the remaining stone was crushed to fragments with a loud report and the walls of the groove had approached each other within about three-quarters of an inch. Other similar movements occur and these take place in a northerly and southerly direction and not in an easterly and westerly line.

In explanation of the Lower Fox River uplift, Mr. Cramer calls attention to the suggestion of Mr. Gilbert that such-like movements may have arisen from the expansion of the rocks

* The geologic agency of lateral pressure exhibited by certain movements of rocks. Proceedings of Boston Soc. of Nat. Hist., vol. xviii, 1876.

† Proc. of the American Assoc. for the Advancement of Science, Eighth Meeting, (1854).

consequent on a rise of temperature since the Glacial Period.* If the Glacial Period had been sufficiently prolonged to have affected the isogeotherms down to a considerable depth where the rocks are in tightly compressed contact, it is conceivable that the rise of temperature in the Post-glacial Period—again assuming a sufficient length of time has elapsed—may have been enough in some instances to create a low domical uplift, but it does not seem to me to be likely that the pressure from this cause could accumulate in surface rocks subject to atmospheric changes over such extended periods.

Before committing myself even to any suggested explanation of these extremely interesting phenomena I was desirous of ascertaining whether the districts described were affected by faulting, and if so to what extent and in which direction. Professor J. W. Spencer, who was staying with me at the time, kindly offered to make enquiries, but I am sorry to say the result has not been very encouraging, indeed very barren. As regards Ohio the State Geologist, Mr. Edward Orton, says that faults are exceedingly rare in Ohio geology but joints are finely shown at Berea; the master joints being a few degrees north of east and the main joints of all the Ohio rocks as far as he can recall the facts, except in one instance, have the same direction.

It appears to me that the cause of these active evidences of lateral pressure must be sought in the differential movements to which it is well known the crust of the earth is subjected. Since the Glacial period, in the British Isles, there are the strongest evidences of vertical movements both of subsidence and elevation having taken place. Having paid great attention both to Post-glacial and Glacial geology during the past twenty years I consider the evidences are overwhelming. Since the marine bowlder clay of the plains was laid down there have been two movements of elevation and two of depression to the extent of several hundred feet† but as the evidences of maximum movement are submerged we cannot estimate it. The well known sand and gravel glacial drift with shells on Moel Tryfan, North Wales, at an elevation of nearly 1400 feet above the sea has long been taken by most English Geologists as convincing evidence of a vertical movement of elevation to that extent since the beds were laid down and notwithstanding the views of some extreme glacialists I must be pardoned if I still consider them a monument of geologically recent elevation. It is true some of the American geolo-

* "Some Geologic Wrinkles," Proc. of American Assoc. for the Advancement of Science, Thirty-fifth Meeting, 1886.

† Geology and Physics of the Post Glacial Period, etc. Proc. Liverpool. Geol. Soc., Session 1871–2.

gists full of scientific enthusiasm have like the late Mr. Bell explained the Tryfan sands and gravels and in addition our bowlder clays as sea bottom pushed up by land ice; but twenty years' careful work in the drift leads me to utterly disbelieve in the universality of this agency. Unless we are to throw on one side all the usual methods of geological investigation it were difficult to believe that current bedded and stratified sand and gravel full of shell fragments to all appearance exactly like a modern beach has been pushed up and landed on the top of a mountain spur—a spur of Snowdon in fact. If the inexorable logic of glacial events in America requires this interpretation I for one prefer to consider that there must be some great flaw in the premises.

Still whoever is right on this point, evidence has been accumulating rapidly on the American side of the Atlantic of glacial and post-glacial elevations and subsidences on a much more prodigious scale. According to Dr. George M. Dawson there have been orogenic disturbances both to the east and west preceding and during the Glacial period amounting to in one case not less than 3000 feet. Laurentian rocks derived from the east are found at elevations on the west amounting to in round figures 4000 feet and several thousand feet above their possible origin. He is of opinion that the subsidence of the Cordillera region of the west was accompanied by an elevation of the Laurentian highlands of the east. All these facts are set forth in his highly interesting presidential address to the Royal Society of Canada.*

The ancient beach lines of the Great Lakes as shown by Gilbert and Spencer evidence considerable differential vertical movements and the latter sees proof from buried river channels and other evidences that the American continent within geologically recent times stood several thousand feet higher than at present and more recently several hundred feet lower. The communication by Prof. J. D. Dana "On the Long Island Sound in the Quaternary Era† points also to considerable differential movements. Mr. Warren Upham has also enumerated a great many instances of Quaternary changes of level in a paper in the Geological Magazine.‡

The Pacific coast in California according to Prof. LeConte and Prof. Davidson of the U. S. Coast Survey give additional evidences of former elevation in the existence of subaqueous river channels as well as evidence of another character existing in some of the islands.

* Trans. of Royal Soc. of Canada, vol. viii, Sec. IV, 1890.
† This Journal, Dec., 1890, pp. 425–437.
‡ Quaternary Changes of Levels, Geol. Mag., Nov., 1890, pp. 492–497.

Taking then for granted the prevalence of these vertical movements in recent geologic times it is obvious that the subsidence of a low arch of elevation must tend to put the surface rocks into lateral compression. This will be largely governed no doubt by the existence or non-existence of faults and joints, and it is readily seen that when the strata are comparatively unbroken and continuous as in Ohio the most favorable conditions prevail. Doubtless the surface rocks adjust themselves to such movements by these anticlinals where they exist and minor subsidences may locally occur. In the Iroquois Beach the rising grade appears to be in a northeasterly direction and to vary from 1·60 feet to 6 feet per mile.*

Were this arch to subside to the horizontal it would be quite sufficient to develop considerable lateral pressure in the surface rocks. So long as the limit of elasticity of the rocks is not exceeded it is quite conceivable that the energy may have been stored up for a great length of time only wanting favorable conditions for its release.

It would take too long to discuss in one paper the cause of these differential vertical movements, but I would refer those interested to Chap. XXII of the Origin of Mountain Ranges where the larger bendings of the earth's crust are treated of. To call in the usual explanation of all lateral pressure phenomena, viz: tangential thrust arising from the shrinking of the earth's nucleus, is to call in an agency which were it the true one would have a more universal effect.

The fact that these conditions of active lateral pressure in surface rocks are recorded as unusual raises a strong presumption that tangential thrust is not the potent agent in geologic change that some maintain, for were it so most of the surface crust would on artificial penetration exhibit powerful signs of pent up energy, for it was clearly proved by me in 1886 and shortly afterwards independently by Mr. Davison that in a cooling solid globe *the greatest compression takes place on the surface* and the same reasoning applies as I have shown in the same work to a globe with a hard crust of the requisite thickness even if the nucleus be molten.

Park Corners, Liverpool, England,
Jan. 2, 1891.

* The Deformation of the Iroquois Beach, by Dr. J. W. Spencer. This Journal, Dec., 1890, p. 447.

ART. L.—*A new Phosphate from the Black Hills of South Dakota;* by W. P. HEADDEN.

THE mineral described in this note was found in the Nimrod, now called the Riverton, lode, near Harney City, Pennington Co., South Dakota. It occurs in the granite common to the district, in kidney-shaped masses, some of them weighing upwards of fifty pounds, but they are not numerous. Externally they are dark brown, due to oxidation which has taken place, in some cases, to the depth of a quarter of an inch, in others only on the surface. These masses enclose a few crystals of white mica, but are not penetrated by crystals of this mineral which often adhere to the surface. Some of them show small seams of an almost white mineral with two cleavages nearly at right angles to one another; its composition has not been determined. It is easily recognized under the microscope, especially in polarized light upon which it acts strongly, while the inclosing mineral has no effect upon it. In places there are dark patches visible only in pieces thin enough to transmit light. The mineral is amorphous and by reflected light has a dark brown color; by transmitted light in very thin pieces it is a yellowish brown, in thicker ones a brown color. It has a resinous-vitreous lustre, an uneven to conchoidal fracture and no cleavage. In thin flakes it is translucent to transparent. Specific gravity, 3·401; hardness, 5·5 and is brittle. It is readily soluble in acids, fuses easily in the flame of a candle and reacts for manganese, iron and soda, before the blowpipe.

The material for analysis was carefully selected, only such pieces being taken as were thin enough to show by transmitted light that they were free from the dark patches and macroscopic seams. The results were as follows:

	I.	II.	III.	IV.	V.	Mean.	Oxygen.		
P_2O_5	38·61	38·22	38·45	38·49	38·86	38·52	·217	2·17—	1
MnO	29·74	29·74	28·97	30·08	----	29·64	·0668		
CaO	7·70	7·66	7·66	7·08	7·28	7·47	·0213		
Al_2O_3	9·94	10·34	10·09	----	10·14	10·13	·0472		
FeO	3·83	4·14	4·01	4·00	....	4·00	·0089		
MgO	0·14	----	0·16	----	---	0·15	·0006	1·977	0·91
Na_2O	5·52	----	5·70	5·68	----	5·52	·0142		
K_2O	0·30	----			----	0·30	·0005		
Li_2O	trace	----	trace	----	----	trace			
H_2O	4·15	----	4·43	----	----	4·29	·0382		
Cl	0·11	...	not det.	----	----	0·11			
F	trace	----	---	----	----	trace			
Insol.	0·14	----	0·18	----	----	0·16			
	100·18		99·65			100·29			

This ratio approaches 1 : 1 and includes the water as basic and the whole of the iron as FeO. If the water be considered as water of hydration, the oxygen-relations cannot be expressed by any simple ratio. If instead of computing the oxygen alone we reckon the atomic equivalents we obtain as favorable a ratio; for, substituting an equivalent number of bivalent atoms for Al_2^{vi} we obtain for the ratio of $P : \overset{iii}{R} : O = 1 : 2{\cdot}49 : 5{\cdot}18$ instead of $1 : 2{\cdot}5 : 5$ or $2 : 5 : 10$ corresponding to the formula $P_2\overset{i}{R}_5O_{10}$ which is a salt corresponding to the normal phosphoric acid H_3PO_5 and in which $R = (MnCaFeH_2Na_2)\frac{5}{4} + Al\frac{1}{4}$. Other complete analyses, than those given were made of less carefully selected material with closely agreeing results.

I would propose to call this new phosphate Griphite, from γριφος *puzzle*, in allusion to its unusual and somewhat enigmatical composition.

A Phosphate near Triphylite from the Black Hills.

A mineral, associated with beryl and spodumene, occurs in nodules in the granite of the Nickel Plate tin claim, Pennington Co., South Dakota. The inner portions of these nodules are nearly free from other minerals while the outer portions contain some small bunches of mica, a few isolated, black, prismatic crystals, which are brown by transmitted light, and here and there small patches of a light brown mineral with resinous luster, conchoidal fracture and one distinct cleavage. Neither the black crystal nor the light brown masses seem to be derived by decomposition, from the surrounding mass as it is wholly unaltered.*

The mineral forming these nodules, is, in the mass, dark green, in thin splinters, it is translucent to transparent and is a light yellowish green; it fuses easily on the edges of thin pieces in the flame of a candle, to a dark brown, magnetic globule and colors the blowpipe flame a faint yellow. It has a hardness of about 5, a specific gravity of 3·612; cleavage in two directions, in one it is perfect in the other it is quite imperfect and the directions are not at right angles to each other. The lustre is vitreous and the fracture uneven to small conchoidal; streak and powder very light green, almost white. When exposed to the atmosphere for a short time it darkens externally due to oxidation. The freshest material was taken for analysis which gave the following results:

* Subsequent examination showed the black prismatic crystals to be crystals of cassiterite with the usual combination of the pyramid and prism, the prism being very strongly developed. Many of these crystals are fretted to such an extent that they form almost skeleton crystals.

	I.	II.	Mean.		At. Eq.		
P_2O_5	38·52	38·76	38 64		54·16	54·66	1
FeO	25·29	24·82	25·05		34·78		
MnO	15·45	15·64	15·54		17·40		
CaO	5·42	5·64	5·53		9·87		
MgO	1·56	1·44	1·50		4·00	81·20	1·5
Na_2O	7·46	(7·46)	7·46	(R_2)	12·02		
K_2O	2·00	(2·00)	2·00	"	2·12		
Li_2O	(·28)	·28	·28	"	1·00		
F	·69	(0 69)	·69	oxygen			
Ignition	·73	(0·73)	·73		223·	223·00	4·09
Gangue	2·49	2 44	2·47				
	99·89	99·88	99 89				

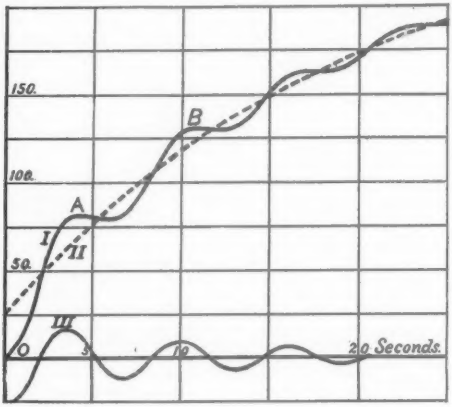
This ratio 1 : 1·5 : 4·09 or 2 : 3 : 8 indicates $\overset{II}{R}_3P_2O_8$ as the formula for the mineral in which the ratio of $\overset{I}{R}_2 : \overset{II}{R}$ is 1 : 4·4 or 2 : 9 giving as molecular formula $2(\overset{I}{R}_2)_3P_2O_8 + 9\overset{II}{R}_3P_2O_8$ or better $4\overset{I}{R}_3PO_4 + 9\overset{II}{R}_3P_2O_8$. The ratio of $\overset{I}{R}_3PO_4$ to $\overset{II}{R}_3P_2O_8$ in triphylite is 1 : 1 but here it is 1 : 2¼, too wide a deviation to admit of their being regarded as identical.

ART. LI.—*Note on Certain Peculiarities in the Behavior of a Galvanometer when used with the Thermopile;* by ERNEST MERRITT, M.E.

(Contributions from the Physical Laboratory of Cornell University, No. 8.)

WHEN a galvanometer, whose needle is not too thoroughly damped, is used in connection with a thermopile, a curious phenomenon is observed. On suddenly exposing one face of the pile to some source of radiant heat, the needle of the galvanometer moves quickly to one side. In a short time, however, the motion becomes less rapid, and in the course of a few seconds the needle comes to rest, and in many cases moves backward for a short distance. This behavior is then repeated, and it is only after a long series of such throws, which gradually become less and less marked, that the final steady deflection is reached. The curve OAB in fig. 1 represents graphically this peculiar motion as observed in the case of a Thomson tripod galvanometer, the abscissa of any point on the curve showing the time that has elapsed since the beginning of the motion, and the corresponding ordinate being proportional to the deflection of the needle from its position of rest. With a galvanometer whose needle is more nearly "dead beat" the maxima and minima which are so clearly shown in the figure, may not be present; but the general form of the curve will still be the same.

The effect described above was noticed in 1884 by Violle * while using a thermopile to investigate the radiation of molten



platinum and silver. Numerous observations of successive maxima and minima are given in his paper; but no explanation of the phenomenon is offered. Messrs. Rubens and Ritter have observed a similar phenomenon with a peculiar form of bolometer which they used for quantitative measurements of electromagnetic waves; † and numerous experiments that have been made in the laboratory of Cornell University with a bolometer of the ordinary type, and with a number of different galvanometers and thermopiles, seem to show that this behavior is not peculiar to any one instrument, but is always observed when a bolometer or thermopile, in circuit with a galvanometer, is *suddenly* exposed to radiant heat. My attention was first called to the phenomenon in 1888, while engaged in an investigation of the energy of the light from incandescent lamps. In a paper‡ published during the following year I called attention to the fact, which at that time rested only upon experimental grounds, that the first throw of the needle, under the circumstances described above, bears a constant ratio to the final deflection, this ratio being independent of the intensity of the radiation to which the pile is exposed.

* "Sur l'etalon absolu de la lumière." Annales de Chimie et de Physique, VI, iii, p. 373.

† "Bemerkung zu den Hertz'schen Versuchen über Strahlen electrischer Kraft." Wied. Ann., vol. xl, p. 63.

‡ "Some Determinations of the Energy of the Light from Incandescent Lamps," this Journal, vol. xxxvii, p. 167.

The phenomenon appears to be due to the inertia of the galvanometer needle, and to the fact that a considerable time elapses after the pile has been exposed to a source of heat, before a constant temperature is reached. On account of its inertia the needle is unable to follow immediately the rapidly increasing current that flows when the face of the pile is first exposed. In a short time, however, the continued action of the deflecting force imparts sufficient velocity to carry it not merely to the position which corresponds to the current then flowing, but to a considerable distance beyond this point. The result is that the motion of the needle is stopped, and a retrograde movement begins, which continues until the pile has been heated sufficiently to cause another throw forward. This behavior is then repeated until the temperature of the pile has become constant, or until the oscillatory motion of the needle has been destroyed by damping. If it be assumed that the heating of the pile takes place in accordance with Newton's Law of Cooling, and that the electromotive force of the pile, throughout the small range of temperatures with which we have to deal, is proportional to the difference in temperature between the junctions, the equation of motion of the needle may be derived as follows:

Let T_0 be the final difference in temperature between the two faces of the pile, and T the difference at any time t. Then the current in the galvanometer is given by the equation:

$$i = \frac{E}{R} = \frac{PT}{R} = \frac{PT_0}{R}(1-\varepsilon^{-kt}) \qquad (1$$

k being the radiation constant of the surface of the pile, and P the electromotive force developed by a difference in temperature of one degree between the two junctions.

The couple due to the action of this current upon the needle, and tending to deflect it, is K $im\,l\cos\theta$, θ being the deflection, and K a constant depending on the form and dimensions of the galvanometer. Since θ is always small, $\cos\theta$ will never differ appreciably from unity. If, therefore, we substitute for i its value as given in (1) and replace $\frac{K\,m\,l\,P}{R}$ by Q, the expression for the deflecting couple is reduced to $QT_0(1-\varepsilon^{-kt})$. The only other forces that act upon the needle are the return force of the earth's field, which for small deflections is equal to $N\theta$, and the retarding effect of damping. The latter force being proportional to the velocity of the needle, may be represented by $L\frac{d\theta}{dt}$. These three forces may now be equated to the product of the moment of inertia of the

needle into its angular acceleration, and thus lead to the following equation of motion:

$$M\rho^2\frac{d^2\theta}{dt^2}+L\frac{d\theta}{dt}+N\theta=QT_0\,(1-\varepsilon^{-kt}) \qquad (2$$

The solution of this equation consists of two parts: (1) the general solution of the "complementary equation" obtained by equating the left hand member to zero; (2) a special solution of the complete equation. The first is readily seen to be the ordinary expression for the motion of a damped needle:

$$\theta = C\varepsilon^{-kt}\cos\left(\frac{2\pi t}{\tau}+\varphi\right) \qquad (3$$

while an easy application of the symbolic method to the complete equation gives the following special solution:

$$\theta=\frac{Q\,T_0}{N}-\frac{QT_0}{M\rho^2k^2-L\,k+N}\,\varepsilon^{-kt}. \qquad (4$$

The complete solution of (2) is the sum of these two parts, and when simplified by the substitution of single letters for the complex coefficients that arise during the integration, gives the following expression for θ:

$$\theta=C\,\varepsilon^{-kt}\cos\left(\frac{2\pi t}{\tau}+\varphi\right)-m\,T_0\,\varepsilon^{-kt}+l\,T_0. \qquad (5$$

The two constants of integration C and φ are determined from the consideration that when t is equal to zero, both θ and $\frac{d\theta}{dt}$ are also zero.

$$C=\frac{\tau}{2\pi}T_0\left\{[m(k-h)+lh]^2+\frac{4\pi^2}{\tau^2}(m-l)^2\right\}^{\frac{1}{2}}.$$

$$\cos\varphi=\frac{l-m}{C}\cdot T_0=\frac{l-m}{C'}.$$

It will be observed that all the coefficients in (5) contain T_0 as a factor, while φ is independent of T_0. The equation may therefore be written:

$$\theta=T_0\left[C'\,\varepsilon^{-kt}\cos\left(\frac{2\pi t}{\tau}+\varphi\right)-m\,\varepsilon^{-kt}+l.\right] \qquad (6$$

The motion represented by this equation evidently possesses all the characteristics of that shown in fig. 1. It may be looked upon as resulting from the combination of two motions, one of them being a steady increase of deflection in accordance with the logarithmic curve represented by the last two terms of the equation, the other a motion of oscillation with grad-

ually diminishing amplitude, as indicated by the first term. Evidently τ is the period of vibration of the needle, and $\frac{h\tau}{2}$ its logarithmic decrement.

To test the above equation a series of observations was made with a Thomson tripod galvanometer, every precaution being taken to secure a constant source of heat, and to avoid errors due to draughts of air, magnetic disturbances, etc. The period of vibration of the needle, and its logarithmic decrement (with the thermopile in circuit) were first determined by the ordinary methods. Data for the curve shown in the figure were then obtained by recording on a chronograph the times of the successive maxima and minima, and the time at which the needle passed each tenth division of the scale. Assuming that the equation derived above truly represented the motion, I then attempted to analyze the curve into its two components, and after a few trials obtained the curves II and III of fig. 1. These two, when combined, give exactly the motion that was observed, while both are capable of being quite accurately represented by equations of the form indicated in (6). For example curve II was found to agree closely with the equation:

$$\theta' = 310 - 283\, \varepsilon^{-0.037t} \qquad (7$$

the differences between observed and computed values of θ' in no case exceeding two per cent. The time of vibration of the needle, as computed from curve III, was found to be 6·1 seconds, while that observed when the needle was allowed to swing freely, was 6·0 seconds. The observed and computed values of the ratio of damping show a similar close agreement, being equal to 1·28 and 1·31 respectively.

The fact, which has already been mentioned, that the first throw of the needle bears a constant ratio to the final deflection, is confirmed by equation (6). Since T_o is a factor of the right hand member of the equation, and since the expression inside the bracket is independent of T_o, the only effect of a change in the intensity of the source of heat would be to increase or diminish all the ordinates of curve I in the same proportion, the ratio of any two ordinates remaining the same. If, therefore, the final deflection of the needle is proportional to the quantity of heat received by the pile, the first throw will also be proportional to this quantity, and may in all cases be used instead of the final deflection. Experiments made in 1888 to test the above conclusion showed the ratio to be constant for deflections ranging from 100^{mm} to 20^{mm}, but for smaller deflections there was apparently a deviation from the law. I have therefore repeated the observations, using great

care to avoid as far as possible all sources of error, and obtain the following results as the mean of a number of measurements:

First throw.	Final deflection.	Ratio.
53·0 mm.	196·0 mm.	0·270
36·5	136·7	0 265
17·75	65·0	0·273
5 25	19·75	0·265

The slight irregular variations which occur might easily be accounted for by the unavoidable errors of observation, especially as the source of heat, an Argand burner, could not be relied upon as perfectly constant. The conclusion that the ratio is independent of the deflection, seems therefore to be justified, at least in the case of the galvanometer used in these experiments.

The importance of this conclusion will readily be seen by those who have had occasion to use a thermopile for accurate measurements of radiant heat. Draughts of air, and other almost unavoidable sources of temperature variation, frequently make the galvanometer quite unsteady, while the extreme delicacy of the instruments that must be used in work of this kind renders them especially susceptible to magnetic disturbances. Many observations are thus made valueless by a change in the zero point of the galvanometer during the three or four minutes required for the needle to come to rest. Only a few seconds are required, however, for the first throw of the needle, and the change in zero point during this time would scarcely ever be sufficient to cause an appreciable error. The use of the first throw in place of the final deflection may therefore lead to greater accuracy as well as to a saving of time.

It will be observed that the principle underlying this method of taking readings is not confined to the case of the thermopile, but is capable of quite wide application. The following are suggested as cases in which the method may be employed with especial advantage:

(1) All ordinary measurements of radiant heat, when the conditions are such as to make the galvanometer unsteady, or when the saving of time is a consideration.

(2) For purposes of demonstration in the lecture room. A number of experiments which are usually considered unavailable for lecture demonstrations have been quickly and accurately performed in this way under conditions that would render the use of the ordinary method entirely out of the question.

(3) For measurements of the heat from a variable source. The first throw of the needle will in this case give the amount of radiant energy at the very instant of exposing the pile.

(4) For work with a bolometer or similar instrument, under the same conditions that apply in the case of the thermopile.

(5) For the measurement of a constant or variable current, where it is desirable for any reason to take readings quickly. For example, the initial value of the current from a cell which is subject to rapid polarization may be determined by the first throw of the needle.

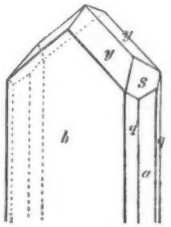
Other applications of the method will doubtless suggest themselves. It is with the hope that a phenomenon which at first appears to be merely a matter of curiosity, may thus be made of practical value in the laboratory, that this note is presented.

ART. LII.—*Supplementary Notice on the Polycrase of North and South Carolina;* by W. E. HIDDEN and J. B. MACKINTOSH.

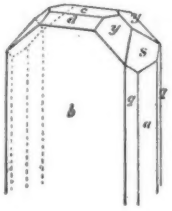
THE occurrence and composition of this mineral were partially announced by us in volume xxxix, pp. 302–306, of this Journal (June, 1890), and the localities have received no development of moment since that publication.

The South Carolina locality is distant about four miles from Marietta, in Greenville County, and is situated otherwise as before described. As to the form of the mineral, we have some interesting features to add to our previous statements and we here subjoin two figures (1 and 2) representing the

1.



2.



two types observed and a corrected list of occurring planes with the angles obtained by using a contact goniometer. The planes observed are as follows, those marked with an asterisk (*) are new:

a (010, $\bar{\imath}$-$\bar{1}$)	d (103, $\frac{1}{3}$-$\bar{\imath}$)*	y (133, 1-$\frac{3}{3}$)
b (100, $\bar{\imath}$-$\bar{\imath}$)	u (011, 1-$\bar{1}$)	z (233, 1-$\frac{3}{2}$)*
c (001, O)*	s (021, 2-$\bar{1}$)	q (130, $\bar{\imath}$-3)

Angles (approx.) observed:

$a \wedge s = 151\frac{1}{2}°$	$b \wedge d = 107\frac{1}{2}°$	$b \wedge z = 117\frac{1}{2}°$
$u \wedge u$ 94°	$b \wedge y$ 104°	$z \wedge y$ 140°
$a \wedge q$ 160°		

These angles closely agree with those recorded for polycrase in Dana's System of Min., p. 523.

Among the South Carolina crystals we observed several apparent twins, one was parallel to s (021, 2-$\breve{\imath}$) and another seemingly parallel to d (103, $\frac{1}{3}$-$\bar{\imath}$). Among the North Carolina crystals one was found quite perfectly twinned parallel to u (011, 1-$\breve{\imath}$). Whenever one of the South Carolina crystals was found terminated at both ends, it was discovered to be hemimorphic in the occurrence of the planes c (001, O) and d (103, $\frac{1}{3}$-$\bar{\imath}$) and invariably *hemihedral* as to the plane z (223, 1-$\frac{3}{2}$); these two features being new to the species.

Figures 1 and 2 were, in several instances, combined in the same crystal; though no crystals were found that had both terminations perfect. Most of the specimens were fragmentary and no crystals or masses were found attached to a matrix. It seems that the one and a quarter kilograms received by us was obtained by washing after the manner of gold mining some kaolinized coarse granite and that this quantity represents nine-tenths of the total amount found at the Marietta, South Carolina, locality (not ten kilos [22 lbs.] as before stated).

Concerning the Henderson county, North Carolina, locality nothing noteworthy has been found there recently.

Our later attempts in the separation of the metallic acids have been somewhat more satisfactory and acting upon a suggestion made to us by Dr. F. A. Genth we made the initial fusion with potassium bi-sulphate (we had previously used the sodium salt). Our results have enabled us to positively identify this mineral as polycrase and to arrive at a very satisfactory formula for the species.

The corrected analyses of two varieties are as follows:—

	Henderson Co., N. C.	Oxygen ratio.		Greenville Co., S. C.	Oxygen ratio.	
Cb_2O_5	19·48	36·35	5·000	19·37	36·14	5·000
TiO_2	29·31	73·27	10·078	28·51	71·27	9·858
Y_2O_3, etc.	27·55*	30·39		21·23†	23·06	
FeO	2·87	4·00	48·73 6·703	2·47	3·43	
UO_3	13·77	14·34		19·47	20·35	48·58 6·719
PbO	----	---	----------	0·46	0·20	
Fe_2O_3	----	----	----------	0·18	0·33	
CaO	----	----	----------	0·68	1·21	
H_2O	5·18	----	28·83 3·965	4·46	----	24·78 3·427
Insol.	----	----	----------	0·12		
SiO_2	----	----	----------	1·01		
	98·16%			97·96%		

* At. w't. = 112.

† At. w't. = 114·1

Inspection of the oxygen ratios shows that when reduced to the simplest terms the relation is, as follows, $Cb_2O_5 : TiO_2 : RO : H_2O = 1 : 2 : 1\frac{1}{3} : \frac{2}{3}$, there being in both cases a slight excess of water which undoubtedly does not enter into the composition of the mineral. The formula which we deduce for the species is therefore $3(Cb_2O_5, 5TiO_2)\ 10(2RO + H_2O)$ or grouping H_2O under the general head of RO we have the simple form Cb_2O_5, $5\ TiO_2$, $10RO$. It is evident that this is not merely an isomorphous mixture of a columbate and a titanate, but that we have a definite salt of a complex inorganic acid, a columbo-titanate properly so-called. It seems also that we are justified in regarding water as an essential constituent. The separation of the metallic acids is even yet not very satisfactory, as our titanic acid shows the presence of columbic acid, but we feel assured that the formula deduced will not be altered by the results of more exact separations.

Regarding the yttria earths present in both varieties we would state that a concentrated solution of them exhibited little if any absorption spectrum and the ignited oxides were of a paler straw color than any we have yet met with, approaching nearly to whiteness in the Marietta mineral.

Prof. Rowland has kindly examined the South Carolina variety spectroscopically in its crude condition, and has identified all the lines of its spectrum, except one or two, as belonging to

Nb, Ti, Yt earths, Sc, Ur, Fe, Pb.

Faint evidences also of Mn, Al, Neo, Di, La, Th (?) and Ce, with the lines of Nb very weak. "There was no Praseo, Di, Ta, Be, Tl or Ge."

He adds that "he has not tried to identify other elements as all the portion of the spectrum examined [i. e. 2 feet out of 10] was satisfied by the above mentioned. The amount of thorium was too minute to be certain of. There was more scandium than in any other mineral he had ever studied spectrographically, except xenotime (from North Carolina) and one exceptional mass of samarskite."

The discovery, by Prof. Rowland, of the presence of scandium in this polycrase adds very materially to its interest.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Speed of Chemical Reactions in Jelly.*—Since the liquid condition of substances is generally regarded as essential to the rapid and uniform progress of chemical changes, Reform-

ATSKY has considered it desirable to test the question whether in the case of slow reactions, the speed is influenced by the passage of the medium into the semi-solid state, like a jelly. For this purpose he selected the katalysis of methyl acetate by hydrochloric acid. Two solutions were prepared: one containing 20 c. c. half-normal hydrochloric acid, with 10 c. c. of water and one c. c. methyl acetate; the other 20 c. c. of the same acid, with 10 c. c. agar-agar solution of 1·25 per cent, and 1 c. c. methyl acetate. These solutions were placed in separate vessels and the temperature regulated by a thermostat to 25°. The strength of the agar-agar solution was so regulated, that at 35° the mixture was completely liquid, while at 25° it was so solid that the vessel could be inverted without showing more than traces of flowing. At the same time, the jelly had so little coherence that it could be drawn into a pipette with a somewhat large opening and could be so far divided by stirring with a glass rod as to permit of titration. Two parallel sets of experiments were made, the c. c. of baryta water required to neutralize the acid in one c. c. of the solution being noted at equal intervals for each solution. The numbers given in the paper show that in both cases the speed of the reaction is the same, within the errors of experiment. This result indeed might have been expected. The speed of chemical changes in homogeneous systems depends not on the greater or less speed of the final masses with regard to each other, but upon that of the molecular motion; so that it is a function not of the interior friction, but of the diffusion-coefficient. Since therefore it has been proved that the speed of diffusion in agar-jelly is the same as in pure water, it follows that the speed of chemical change cannot be materially altered by the presence of the jelly. Still it was important to establish this result by direct experiment.—*Zeitschr. physikal. Chem.*, vii, 34, Jan., 1891. G. F. B.

2. *On the Direct-reading of Volumes in Vapor-density Determinations.*—LUNGE and NEUBERG have applied the apparatus, contrived by the former chemist for the direct reading of gas volumes,* to the determination of vapor-densities. For this purpose they attach the Meyer bulb to the measuring tube in place of the gas evolution flask. After the vapor in the bulb has expelled the corresponding volume of air, the pressure tube is raised until the level of the mercury in the reduction tube reaches the normal mark. Since under these conditions the gas-volume is also at the normal pressure and temperature, this volume may be directly read off. If this reading is in cubic centimeters, g grams of the substance give v cubic centimeters of vapor, and the density $D=g/v$. 0·001293. By this method the vapor density of benzene was determined as 2·66 – 2·76, that of naphthalene 4·2, that of triphenyl-methane 8·24, and that of mercury 6·8. In all these cases except the first, the temperature of determination was below the boiling point of the substance; the value of mercury for example being obtained in the vapor of diphenyl at 254°, the

* This Journal, III, xxxix, 396, May, 1890.

boiling point of mercury itself being 359.—*Ber. Berl. Chem. Ges.*, xxiv, 729, March, 1891. G. F. B.

3. *On Hydrazoic Acid.*—Further observations upon azoimide or hydrazoic acid N_3H, have been published by CURTIUS in connection with RADENHAUSEN. They have succeeded in isolating the anhydrous gas in the pure state and find that it is permanent only at temperatures above 37°. Below this even at the atmospheric pressure it condenses to a clear colorless mobile liquid, which is highly explosive, and which possesses the intolerable odor of the gas. The liquid is readily miscible with water or alcohol. On fractionating the concentrated aqueous solution four times, an acid was obtained containing over 90 per cent of N_3H. From this the last traces of water were removed by means of fused calcium chloride. The anhydrous liquid thus obtained is found to boil at 37°. When suddenly heated, it explodes with extraordinary violence with a vivid blue flame. In a Torricellian vacuum it explodes spontaneously at the ordinary temperature; the explosion under these circumstances of only five centigrams being sufficient to pulverize the apparatus completely, driving the mercury in the form of dust into every corner of a large laboratory. On one occasion, about 0·7 gram suddenly exploded on removing the tube containing it from a freezing mixture in which it had been immersed. Every glass vessel in the vicinity was completely shattered by the concussion and one of the authors was seriously injured. By determinations of its conductivity, Ostwald finds this acid to be a little stronger than acetic acid. Moreover, the authors have not succeeded in effecting the change of the ammonium salt N_3NH_4 into an isomeric substance, as suggested by Mendeléef. The ammonium salt itself crystallizes in fine large prisms, which grow continually smaller and finally disappear, by continuous sublimation.—*Nature*, xliii, 378, Feb. 1891. G. F. B.

4. *On the Production of Arabinose from Wheat bran.*—STEIGER and SCHULZE have shown that, when wheat bran, freed from starch and albuminous matter, is boiled for several hours with a three per cent sulphuric acid, the acid removed by barium carbonate, the solution filtered, evaporated and extracted with alcohol, there crystallizes out arabinose on evaporation of the alcohol. It is probably formed by the hydrolysis of metaraban, a constituent of the cell membrane which cannot be obtained pure but which gives a cherry-red color on warming with hydrochloric acid and phloroglucinol.—*Ber. Berl. Chem. Ges.*, xxiii, 3110, October, 1890. G. F. B.

5. *On distinguishing Arsenic from Antimony.*—DENIGÈS proposes to distinguish between the deposits of arsenic and antimony by the fact that if the stain obtained by Marsh's test is placed in a porcelain capsule and heated with a few drops of pure nitric acid, and then treated with a small quantity of ammonium molybdate dissolved in nitric acid, the antimony deposit gives no precipitate while arsenic forms arseno-molybdic acid which separates

as a yellow precipitate. This under the microscope is seen to consist of stellate crystals with triangular arms, generally six, arranged in rectangular planes along the axes of a cube, and which polarize light. The author regards this as the most sensitive and distinctive test for arsenic. He prepares the ammonium molybdate solution by dissolving ten grams of this salt and 25 grams of ammonium nitrate in 100 c. c. of warm water. After cooling, 100 c. c. of pure nitric acid of sp. gr. 1·20 are added drop by drop with active stirring. Then the liquid is heated on the water bath for ten minutes, allowed to cool and after 48 hours, filtered.—*C. R.*, cxi, 824; *J. Chem. Soc.*, lx, 364, March, 1891.

G. F. B.

6. *On Priestley's Eudiometric method.*—The method adopted by Priestley for measuring the oxygen in the air by mixing a measured volume of nitrogen dioxide with it and noting the diminution of volume, has been condemned as inaccurate. WANKLYN has investigated the matter and concludes that the inaccuracy is due to the oxygen present in the water through which the gas is made to pass. This source of inaccuracy may be avoided by using a Hempel apparatus and measuring the air in the gas burette and then passing it into an absorption pipette containing water. The nitrogen dioxide is introduced into the gas burette and measured and then (without bubbling through water) passed into the air in the absorption pipette. After the nitric tetroxide formed has been absorbed by the water in the absorption pipette the gas is passed back into the gas pipette and is again measured.—*J. Chem. Soc.*, lx, 362, March, 1891. G. F. B.

7. *On Crystalline Liquids.*—Attention has been drawn by LEHMANN to the fact that the optical behavior of certain liquids is such as to suggest a crystalline structure in them. Chemically however these liquids are homogeneous and their anisotropic character is not due to external stress. He now raises the question whether liquids which are isotropic are non-crystalline, or whether they are crystalline and isometric. In view of the free miscibility of liquids, however, he concludes that they are non-crystalline, since were this not the case they could mix only with isomorphous substances. This conclusion the author supports by experiments on the miscibility of crystalline liquids with each other and with solid crystals. Liquid crystals, when heated between cover glasses to a point slightly above that at which they pass into ordinary liquids, retain on cooling the original direction of their optic axes owing probably to condensation and consequent higher melting point of a layer on the surface of the glass. Isomorphous liquid crystals exhibit the phenomena of diffusion and hence the capability of solids to form mixed crystals appears to correspond exactly with the process of mixing or diffusion in liquids.—*Ann. Phys. Chem.*, xli, 525.—*J. Chem. Soc.*, lx, 249, March, 1891.

8. *On the Refractive indices of Water.*—BRÜHL has measured the refractive indices of water for light of certain wave-lengths

not hitherto employed. These are the double red line of potassium, of wave-lengths 0·770 and 0·767 μ, and the δ line of hydrogen, coinciding with the Fraunhofer line *h*, and of wave-length 0·4101 μ. In order to obtain the necessary brightness, the potassium bead was made of a mixture of potassium perchlorate and chloride; and it was placed at the point of the reduction-cone of the Bunsen flame. For the H_δ line, end-on spectrum tubes were employed, the light being bright enough to show even H_ε. Besides these lines, those of lithium, sodium and thallium were also used, and the lines H_a H_β, and H_γ in addition. A Fuess spectrometer reading to thirty seconds was employed, the minimum-deviation adjustment being secured for each kind of light and for each temperature. The following are the results obtained, each value being the mean of a series of measurements which the author believes correct to the fourth decimal place at least:

Temp.	K	Li	H_a	Na	Tl	H_β	H_γ	H_δ
19·9°	1·32888	1·33088	1·33120	1·33305	1·33493	1·33720	1·34045	1·34239
23·7°	1·32881	1·33077	1·33091	1·33280	1·33468	1·33692	1·34016	------
25·3°	1·32852	1 33041	------	1·33249	1·33447	------	------	------
26·0°	------	------	1·33050	------	------	1·33625	------	------
27·0°	1·32830	1·33033	------	------	1·33428	------	------	------

These results are compared with those obtained by v. d. Willigen, Landolt, Wüllner and Rühlmann for all the lines except K_a and H_δ and show a close accordance.—*Ber. Berl. Chem. Ges.*, xxiv, 644, Mch. 1871. G. F. B.

9. *Genesis of the Elements.*—Professor William Crookes closes a most interesting address before the Institution of Electrical Engineers on the subject "Electricity in transitu: from plenum to vacuum," with the following remarks on the genesis of the elements:—

It is now generally acknowledged that there are several ranks in the elemental hierarchy, and that besides the well-defined groups of chemical elements, there are underlying sub-groups. To these sub-groups has been given the name of "meta-elements." The original genesis of atoms assumes the action of two forms of energy working in time and space—one operating uniformly in accordance with a continuous fall of temperature, and the other having periodic cycles of ebb and swell, and intimately connected with the energy of electricity. The centre of this creative force in its journey through space scattered seeds, or sub-atoms, that ultimately coalesced into the groupings known as chemical elements. At this genetic stage the new-born particles vibrating in all directions and with all velocities, the faster-moving ones would still overtake the laggards, the slower would obstruct the quicker, and we should have groups formed in different parts of space. The constituents of each group whose form of energy governing atomic weight was not in accord with the mean rate of the bulk of the components of that group, would work to the outside and be thrown off to find other groups with which they

were more in harmony. In time a condition of stability would be established, and we should have our present series of chemical elements, each with a definite atomic weight—definite on account of its being the average weight of an enormous number of sub-atoms, or meta-elements, each very near to the mean. The atomic weight of mercury, for instance, is called 200, but the atom of mercury, as we know it, is assumed to be made up of an enormous number of sub atoms, each of which may vary slightly round the mean number 200 as a centre.

We are sometimes asked why, if the elements have been evolved, we never see one of them transformed, or in process of transformation, into another. The question is as futile as the cavil that in the organic world we never see a horse metamorphosed into a cow. Before copper, e. g., can be transmuted into gold, it would have to be carried back to a simpler and more primitive state of matter, and then, so to speak, shunted on to the track which leads to gold.

This atomic scheme postulates a to-and-fro motion of a form of energy governing the electrical state of the atom. It is found that those elements generated as they approach the central position are electro-positive, and those on the retreat from this position are electro-negative. Moreover, the degree of positiveness or negativeness depends on the distance of the element from the central line; hence, calling the atom in the mean position electrically neutral, those sub-atoms which are on one side of the mean will be charged with positive electricity, and those on the other side of the mean position will be charged with negative electricity, the whole atom being neutral.

This is not a mere hypothesis, but may take the rank of a theory. It has been experimentally verified as far as possible with so baffling an enigma. Long-continued research in the laboratory has shown that in matter which has responded to every test of an element, there are minute shades of difference which have admitted of selection and resolution into meta-elements, having exactly the properties required by theory. The earth yttria, which has been of such value in these electrical researches as a test of negatively excited atoms, is of no less interest in chemistry, having been the first body in which the existence of this sub-group of meta-elements was demonstrated.

10. *Geschichte der Photographie ;* by C. SCHIENDL. pp. 380, small 4to, Vienna (Hartleben).—The author commences with a brief review of what few observations were made by the ancients upon the action of light, which seem to have amounted to very little, and then passes to the early beginnings of photography in modern times. These chapters are full of interest. From his investigations the author concludes that the first actual image produced by light was obtained by J. H. Schulze in 1727 who observed that a mixture of nitric acid, silver nitrate and lime in excess produced a compound which darkened in sunlight but that the portion under the piece of cord, which he tied around the flask

in which the matter was contained, remained white. Only at long intervals were further steps made. Thirty years later Beccaria made the observation that the coloring of silver chloride was due to the action of light and not as previously supposed, to that of the air. In weighing the relative claims of Nicéphore Niépce and of Daguerre to the actual discovery of photography the author is disposed to believe that the former has received too little and the latter more than his due share of the honor. The discoveries which rapidly followed after this are next described and the author has evidently devoted much care and thought to the presentation as well of the theoretical views as of the practical processes which have been brought forward up to the present time.

The book seems to deserve a translation into English. M. C. L.

11. *Die Elektrischen Verbrauchsmesser von* ETIENNE DE FODOR. 219 pp. 12mo. Vienna, 1891.—Electro-technical Library, vol. xliii (A. Hartleben). The electro-technical library, the earlier issues of which have been noticed in the Journal, has grown to upwards of 40 volumes covering a wide range of topics. It would be difficult to find elsewhere so much direct practical information on subjects dealing with the technical application of Electricity, as is compressed into these little volumes. The present issue takes up the subject of Electric meters and with great fullness gives the many forms that have been devised, from the earliest kinds first described to those now found most practically useful. The forms described are so numerous that the account of each is brief, but the abundance of illustrations adds much to the completeness of the treatment.

12. *Das Totalreflectometer und das Refractometer für Chemiker*, ihrer Verwendung in der Krystalloptik und zur Untersuchung der Lichtbrechung von Flüssigkeiten von Dr. C. PULFRICH. 144 pp. 8vo, with 4 plates. Leipzig, 1890 (Wm. Engelmann).—This volume contains a thorough discussion of the theory and practical use of the new form of totalreflectometer, first described by the author in 1887 (Wied. Ann., vol. xxx, p. 193). The method consists, in a word, in determining the critical angle for the light-ray which has passed from below into a glass cylinder and suffered total reflection from the surface of the substance under examination placed upon the plane surface of the cylinder. The required refractive index is given by the equation $n = \sqrt{N^2 - \sin^2 i}$ where N is the index for the glass and i the angle of emergence. By using different kinds of glass from N = 1·95 to 1·60, refractive indices from 1·675 to 1·249 may be determined. The method is easy of application and, as shown by measurements by the author and others by Mühlheims, capable of giving accurate results. A special chapter describes the modification of the instrument as designed for the use of chemists in the measurement of refractive indices of solutions.

13. *Appleton's School Physics;* embracing the results of the most recent researches in the several departments of Natural

Philosophy by J. D. QUACKENBOS (literary editor), A. M. MAYER, F. E. NIPHER, S. W. HOLMAN, F. B. CROCKER. 544 pp. New York, Cincinnati, Chicago, (Amer. Book Co.—D. Appleton Co.'s Press). It is satisfactory to receive an elementary work on Physics which, like the one in hand, is fresh and new throughout, and not an abridged reproduction of matter and illustrations which have done duty for many years. The limitations of a book for early students in a subject so large and profound are severe, and it would not be difficult here to find points to criticize, but the manner in which the several editors have done their work is deserving of decided commendation. The simplicity of the treatment and the practical character of the illustrations make the book particularly well suited for the class of students for which it is written; it should have a wide sphere of usefulness.

14. *Handwörterbuch der Chemiker.* By Dr. CARL SCHAEDLER. 12mo, pp. vi, 162. Berlin, 1891 (Friedlander).—A series of brief biographical sketches of eminent chemists and physicists. The Americans noticed are the two Sillimans and Remsen.

15. *Bibliotheca Polytechnica:* a Directory of Technical Literature. By V. SZCZEPANSLI. 12mo, pp. 80. New York, 1890. (Int. News Co.).—A classified catalogue of technical books and periodicals published in America and Europe.

II. GEOLOGY AND NATURAL HISTORY.

1. *On the Rock-fracture at the Combined Locks Mill, Appleton, Wisconsin;* by FRANK CRAMER. (Communicated.)—It was impossible, after the upheaval of a part of the pulp-mill at the Combined Locks, in September, 1889,* to get direct evidence of movement in the underlying rock. During the past summer, the water was pumped out of the tail-race for the purpose of deepening the latter, and this gave an opportunity to examine the rock layer on which the mill rests. It will perhaps be well to describe the fracture in the rock under the mill, to show how accurately the cause was registered in the effects.

What the extent of the disturbance was just outside of the cement pier and above the dam, cannot be known. But inside, under the mill, the crack in the rock begins directly under the big crack in the pier and runs under the piers supporting the sixth, seventh and eighth machines and close to those supporting the third, fourth, fifth, ninth and tenth machines. It passes out under the sixth and seventh windows and ends in the quarry in the tail-race just below the mill. The rock is lifted into a low ridge which gradually dies away toward the quarry. The effects of the compression are most marked near the big pier. Here the rock on one side of the fracture is lifted nearly a foot, while on the other side it has fallen back nearly into its original position, leaving a fault of eight inches. Along the line

* See this Journal, xxxix, 220, 1890.

of fracture the rock is broken into pieces varying in size from a few square inches to several square yards. The fault disappears where the crack passes out from under the mill; and here the splintering is confined to a depth of two or three inches and a width of four or five. The chips vary in size from half an inch to two or three inches square, and many of them are scarcely thicker than a sheet of paper. Beyond this the ridge, the fault and the crushed rock disappear and there is nothing to indicate a disturbance, except a clean fracture, which ends in the quarry.

There have been observed, in this region, two or three other cases of fracture which will throw light in the search for the cause of the fracture at the Combined Locks. Between the last two locks in the government canal at Kaukauna, about sixteen inches of the upper rock layers had been removed, leaving a layer three and a half inches thick at the surface in the bottom of the canal. Before navigation opened last spring the canal bed was examined, and this upper layer was found fractured and raised into a ridge for a distance of about twenty-five feet along a line of drill-holes that had passed through it. It was proved beyond a doubt by the conditions observed on the spot and by the testimony of men who helped remove the rock in the canal, that the ridge was not formed until at least one season after the canal had been finished and in use. The one layer was raised sixteen inches, leaving a hollow underneath. The fracture passed along the line of the drill-holes, and formed the axis of the ridge. Its direction was N. 20° E. parallel with that of the canal and the river.

Only a few hundred feet away from the canal another break in the rock occurred in June, 1889. At this point the high clay bluff bends away from the river, leaving a large flat, but little above the river level, and with the rock almost bare of soil. On this flat, at the south end of private claim 33, there was a quarry four and a half feet deep. A six-inch layer of limestone formed the floor of the quarry, at one end of which a hole seventeen inches deep had been blasted as a start for the next "level." The water was pumped out of the quarry in June; and after four or five days of warm weather, while some men were working just behind a knoll, they heard a noise which they described as being like that of exploding dynamite. The layer forming the floor of the quarry was fractured; the crack started from the hole at one end and ran down the middle of the quarry for some distance, and then bifurcated, the branches running to the two corners at the south end. The rock was lifted into a ridge sixteen inches high, and in some places split into thin plates. The fracture ran at right angles to the river and the high clay bank.

A paper mill has recently been built at Kimberly, three miles down the river from Appleton, and three miles up the river from the Combined Locks. A large quarry four feet deep was opened in the river bed below the government dam. While Mr. Charles Riggs, the contractor, and the men at work in the quarry were

eating dinner one bright day, they heard a snapping noise. The rock in the bed of the quarry was ripping. The disturbance started at the lower end, traveled up the river, and ended in a wheel-pit fifty feet square and four feet deep. It required several seconds to make the trip, and shook up the "quarry chips" that covered the bottom of the quarry to the depth of about a foot. Later, when the covering of the chips were removed and the quarry cut deeper, it was found that the first eight inches of the rock was broken by a clean fracture, but below that, was much crushed. How far down the crushed condition extended is not known; the quarry was made two feet deeper, and crushed rock was still in sight. The direction of the crack was N. 45° E.

When the several cases of fracture described above, all of which occurred in the compact Galena limestone of the Fox River valley, are considered together, it becomes clear that the weight of the clay plain had nothing to do with their production, for some of them run parallel with the river and the high clay banks, and others make high angles with them. And, further, there is no parallelism among the cracks themselves. The times of the year and other conditions under which the disturbances occurred make it impossible to assign a common local cause for them, and it is as difficult to point out a separate cause for each. It seems evident that the cause of the fractures is a condition of the rock itself; and that in this region it is suffering compression in all directions. The local character of the disturbances is well illustrated by the fracture at the Combined Locks, where at one end there were crushing, uplifting and faulting, and less than 125 feet away there is nothing but a simple fracture. The direction of fracture seems to be determined, not so much by preponderance of pressure in a particular direction as by the artificial relief given in each case. The local conditions, perhaps even including barometric disturbances, seem to furnish nothing but the occasions for the action of the general cause. The facts are in harmony with Gilbert's theory that the superficial strata have expanded in consequence of their rise in temperature since the close of the glacial period. But more data are needed for a demonstration.

Lawrence University, Appleton, Wis., Jan. 10, 1891.

2. *Bulletin of the Geological Society of America, Vol. II.*— The papers read at the December meeting, already published, include the following: C. L. Herrick, on the Cuyahoga Shale, and the problem of the Waverly; G. F. Becker, on the structure of a portion of the Sierra Nevada; Ed. V. D'Invilliers, on the Navassa phosphate deposits; A. Winchell, a last word with the Huronian; C. W. Hayes, on the overthrust faults of the Southern Appalachians; Robert Bell, the nickel and copper deposits of Sudbury District, Canada, with an appendix on the silicified glass-breccia, by G. H. Williams; Geiger and Keith, on the strucure of the Blue ridge near Harper's Ferry; G. M. Dawson, Geological structure of the Selkirk range; G. F. Becker, on Antiquities

under Tuolumne Table Mountain, Cal., and notes on the early Cretaceous of California and Oregon; R. Pumpelly, on the relation of Secular rock-disintegration to certain transitional crystalline Schists; A. Winslow, on the geotectonic and physiographic geology of Western Arkansas; W. Upham, on Glacial lakes in Canada; C. R. Keyes, stratigraphy of the Carboniferous in Central Iowa; E. Brainerd, on the Chazy in Champlain valley; G. H. Williams, on the petrography and structure of the Piedmont Plateau in Maryland, with a supplement by C. R. Keyes; J. Le Conte, on the Tertiary and Post-tertiary changes of the Atlantic and Pacific Coasts; J. E. Wolff, on the Lower Cambrian age of the Stockbridge limestone; H. D. Campbell and W. G. Brown, composition of Mesozoic igneous Rocks of Virginia; W. H. Weed, on the Cinnabar deposits and Bozeman coal fields of Montana; H. W. Turner, on the Geology of Mount Diablo, Cal., with a supplement on the chemistry of the rocks by W. H. Melville.

3. *Cambrian fossils in the Stockbridge limestone of Vermont.*—J. E. Wolff, in his paper in vol. ii of the Bulletin of the Geological Society of America (page 331), mentions the very important discovery of Lower Cambrian fossils in the great central limestone belt of Vermont, at several localities in the vicinity of Rutland. The fossils are a species of *Kutorgina*, and a *Salterella*, much like *S. currata* of the Olenellus Cambrian of North Attleboro, Mass. The limestone belt has, on its east side, with conformable bedding, the Green Mountain quartzyte, which Walcott proved, by the discovery of fossils, to be Lower Cambrian. West of the Limestone belt and dipping beneath it there is a second quartzite, that of Pine Hill, which also is referred to the Olenellus Cambrian. West of this there is a Center Rutland belt of limestone which was proved by fossils to be of Lower Silurian age, like that of the West Rutland limestone. Dr. Foerste was associated with Mr. Wolff in the discoveries.

4. *Geological Survey of Kentucky.*—This survey under John R. Procter, Director, has recently issued a report on the Geology of Clinton County, by R. H. Loughridge, M.D., and another on Whitley County and a part of Pulaski, by A. R. Crandall, assistant. Each is illustrated by a colored geological map, and the latter also by several plates.

5. *Geological Survey of Missouri.*—Bulletin No. 4 of this Survey contains descriptions of a large number of new species of Crinoids, from the Subcarboniferous beds of Missouri, by S. A. Miller, with figures illustrating them on four plates. A Biennial report by Mr. Winslow, the State Geologist, has recently been issued, which gives a sketch of former geological surveys in Missouri, and an account of the work now going forward.

6. *Geological Survey of Arkansas.*—J. C. Branner, State Geologist. The annual report for 1889, vol. ii, covering 283 pages, is devoted to an excellent detailed account of the geological structure and the resources of Crowley's Ridge, by R. Ellsworth Call. Crowley's Ridge, the only marked prominence in the

country between Little Rock and Memphis, rises usually over a hundred feet above the level of the country on either side of it. A colored map accompanies the report.

7. *Geological Survey of Texas.*—The annual appropriation for the Geological Survey of Texas, made by the Legislature just adjourned, is $35,000, exclusive of printing. Appropriations were also made for testing the lignites, for the publication of an accurate map of the State, and for the erection of a laboratory building at the University of Texas, which will contain a suite of rooms for the chemical department of the Survey.

8. *Geological Survey of Alabama.* — Professor Eugene A. Smith informs the editors that the last legislature of Alabama placed the annual appropriation for the geological survey at $7500, and made it continuing, i. e. till otherwise provided by law. This puts the survey on a very desirable footing as to permanence as there will be no effort to bring the work to a close so long as there is anything to report upon, which in the case of such a state as Alabama, will be a long while. The printing, engraving, etc., are paid for out of another fund, which leaves the whole amount of the appropriation to be devoted to the defraying of the general expenses of the survey. The first work to be undertaken will be the detailed mapping of the Warrior and Coosa Coal Fields.

University Ala., Feb. 23, 1891.

9. *A Bibliography of Palæozoic Crustacea from 1698 to 1889*, including a list of North American species and a systematic arrangement of genera; by ANTHONY W. VOGDES. 1890. 117 pp. (U. S. Geological Survey, Bulletin 63).—This work, which has been long announced, will meet a warm welcome from students of fossil Crustacea. The bibliography (Part I), extending from pp. 13–78, is a compilation noteworthy for its few omissions, and is unquestionably the most exhaustive analysis of the literature of these fossils yet produced. The citations consist of the titles in full, with a summary of the genera discussed, and frequent critical notes upon genera or species. An excellent feature of these citations is the more extended notice given to works of early date and those accessible with difficulty. If future editions would give, even at the necessity of considerable increase in size, the names of species as well as genera discussed in each work cited, it will prove a valuable addition. Species are the important units; generic values are constantly varying with the increase of knowledge. Part II is a systematic catalogue of the North American Paleozoic Trilobita, preceded by a brief synoptical table of genera and Part III is a similar list of the non-trilobitic species. In these catalogues Captain Vogdes has kept himself singularly free from the expression of personal convictions of generic and specific values, preferring to accept the latest results of reliable investigation as standards. In this respect the catalogue possesses a value not shared by previous attempts in this direction which have been carried on without special familiarity

with these fossils. The author's convictions are however often apparent, even when not enforced. For example, he adopts the term *Trinucleus*, though expressing the opinion that Dr. Green's *Cryptolithus* is entitled to acceptance; again the genus *Acidaspis* is retained in its broad and current usage, though Captain Vogdes himself has at an earlier date warmly and justly espoused the precedence of Warder's term, *Ceratocephala;* in these and other instances evincing his consideration for the convenience of those who will make the most use of the work. But two new generic names are proposed, *Lloydia* (in honor of Edward Llhwyd "the first author on Trilobites") for the species *Bathyurus bituberculatus* Billings, and *Strigocaris*, in place of *Solenocaris* Meek, a preoccupied term. The catalogue of non-trilobitic genera is preceded by a scheme of classification which is open to objection in some respects. The author does not choose to recognize Packard's order *Phyllocarida*, but divides the *Phyllopoda* into the *Ceratiocaridæ*, *Discinocaridæ* and *Rhinocaridæ* and in the last family are placed *Estheria*, *Leaia* and *Schizodiscus* (perhaps the only genuine phyllopods in the list) as well as the genus *Mesothyra*, which belongs to the distinct family, *Pinacaridæ*.

The entire work is unfortunately abundant in typographical errors, few, however that need cause serious annoyance. Some of these have already been corrected in a supplement issued by the author privately, and it may be expected that others will be eliminated in the future editions which, it is hoped, so valuable a catalogue will attain. J. M. C.

10. *On the Organization of the Fossil Plants of the Coal-Measures;* by W. C. Williamson. Pt. XVII. Phil. Trans. Roy. Soc. London, vol. 181. 1890, B, pp. 89–106, pl. XII–XV.—Part XVII of this series of valuable memoirs is important for the evidence which it contains of the discovery of an exogenous development among the Carboniferous ferns. The anticipation expressed by the author in Part IV that *Dictyoxylon* (*Lyginodendron*) *Oldhamium*, there described as belonging to Paleozoic Proto-gymnosperms might be identical with the petioles described, at the same time, as Edraxylon, and later (Pt. VI) as *Rachiopteris aspera*, is now confirmed, and the two are conclusively proved to be trunk and petiole of the same plant. The origin of the trachæal bundles of the petiole in the middle cortex of the trunk and the formation of the medulla in the center are described with the author's customary accuracy and minuteness of detail. As the medulla expands during the growth of the petiole, there is a corresponding increase in the number of vascular laminæ, the inner extremities of which, though commencing their growth at different periods of life, all start from the medullary border of the vascular zone and extend to the periphery. The number of these laminæ were observed to vary from 44 in a small specimen, in which the medulla was present, to 1120, similarly arranged, in a large one. Not only has Prof. Williamson examined many specimens showing the transition stages between the two types, but

his studies include specimens in which stem and petiole are organically united, thus rendering more conclusive the proof that *Lyginodendron Oldhamium* is a true fern, probably belonging to the Sphenopterids, and that the stems of some, at least, of the Carboniferous ferns "developed their xylene or vascular structure exogenously through the instrumentality of a meristemic zone of the innermost cortex, which practically must be regarded as a cambium layer." D. W.

11. *Catalogue of the Fossil Cephalopoda in the British Museum, Part II;* by ARTHUR H. FOORD.—Although nominally a catalogue, this work possesses the nature of a monograph, and is a positive contribution to the literature of the subject. A full bibliographical notice is given of each genus and species, together with detailed descriptions of the principal characters. The present volume includes the families Lituitidæ, Trochoceratidæ, and Nautilidæ. The text is enriched with numerous wood-cuts drawn by the author. C. E. B.

12. *Mineralogical notes*, by W. E. HIDDEN and J. B. MACKINTOSH. (Communicated). *Auerlite.*—The lemon-yellow variety found on Price's Land in Henderson County, N. C., has proved to contain more P_2O_5 and correspondingly less SiO_2 than that from the Freeman Zircon Mine, three miles northeasterly in the same county. The density varies between 4·051 and 4·075. The ratio of $P_2O_5 + SiO_2 : H_2O$ is the same as is demanded by the formula deduced from the former analyses. It is to be noted that the density decreases as the percentage of phosphoric acid increases. Among the crystals we have observed twins parallel to 1-*i*, as in zircon, rutile and cassiterite. The analysis has given :

		Molecular Ratio.		
P_2O_5	8·58 × $\frac{5}{142}$	362	}	·590 = 1
SiO_2	6·84 × $\frac{2}{60}$	·228	}	
ThO_2	[72·15] × $\frac{2}{264·5}$	·553	}	×2 1·172 = 2
Fe_2O_3	1·78 × $\frac{3}{160}$	·033	}	
H_2O	10·64 × $\frac{2}{18}$	1·182		= 2
	100·00			

The thoria was tested and found to be quite pure but was unfortunately lost before it could be weighed. The percentage above given is determined by difference. The above analysis confirms the formula previously assigned by us to this mineral (see this Jour., Dec. 1888, p. 462) i. e.,—ThO_2, $\left\{ \begin{matrix} SiO_2 \\ \frac{1}{3}P_2O_5 \end{matrix} \right\}$ $2H_2O$ or a thorite (orangite) in which part of the silica is replaced by its equivalent in phosphoric acid, when $3SiO_2 = 1P_2O_5$. The P_2O_5 tends to be in excess.

Sulphohalite [$Na_2(\frac{3}{4}SO_4, \frac{1}{4}Cl)$].—A careful examination of the few crystals available has proved an apparent tendency to hemihedrism, the octahedral faces being present only on the alternate trihedral solid angles of the dodecahedron. This, if confirmed,

would make the species tetrahedral like boracite, but this we cannot however assert positively on account of the present rarity of the mineral. Besides these faces of the octahedron (or tetrahedron) we have also observed the cube modifying the rhombic-dodecahedron. One very perfect crystal contained an irregular cavity full of a liquid in which was a moving bubble of air (or gas.) It also showed, by transmitted light, numerous lines of growth parallel to all the planes.

*On the composition of the Fayalite from Cheyenne Mt., Colorado.**—This mineral has the high specific gravity of 4·35, shows cleavage, (imperfect) at right angles in two directions, is fusible and gelantinizes with acids. It occurred in this instance as a mass weighing nearly ten pounds and was quite abundant in the vicinity in the granite. Analysis leaves no doubt as to its nature. The results were:

	1.	2.
SiO_2	27·30	27.66
FeO	5·83	65·794
MnO	----	4·17
CaO	----	0·47
		98·24

The iron may be present in both the ferrous and ferric state but this point was not determined, or the reasons for the loss ascertained.

13. *Mineralogical Notes;* by W. E. Hidden, (communicated.) —*Remarkable discovery of Bastnaesite and Tysonite.*—In the summer of 1889, Mr. J. G. Hiestand, of Manitou Springs, Colorado, brought to my attention and sent samples of a new discovery of bastnaesite and tysonite, which he had made in the Pike's Peak region, at no very great distance from Manitou. He reports that the total quantity found weighed over six kilograms and was originally all included in one great group or mass. Hexagonal tabular crystals, somewhat modified, nearly two inches across, of a clear deep brown color, made up the exterior layers of the larger fragments while the interior and greater portion was composed of the wax-yellow unaltered tysonite, in parts perfectly transparent. The specific gravity of several fragments was found to be only 6.007. For novelty's sake a gem was cut that weighed two-thirds of a gram, but it did not have very much brilliancy. Some sections were made for optical examination and have been sent to Prof. Penfield for that purpose.

A white mineral of an earthy nature and seemingly a product of alteration occurs in the bastnaesite and tysonite in large patches. Its specific gravity = 4·145. It lost 21·02 per cent after being strongly ignited and was then wholly soluble in HNO_2 making a deep red solution, (Ce). It may prove to be a mixture of bastnaesite with lanthanite.

* See this Journal, March, 1885, p. 250.

Four new localities of Fergusonite.—Along with the orthite found near Amelia Court House, Virginia, I have discovered a few small crystals of fergusonite implanted upon it at right angles and projecting into the feldspar matrix to a depth, in some instances of 18 to 20^{mm}. The prisms were square with very dull gray surfaces, but were brilliant resinous on a fractured surface. The terminations were obscure but traces of acute octahedra were noticed. Sp. grav. varied from 5·1 to 5·6. No analysis was attempted.

With the three hundred or more pounds of zircon mined by the writer in the near vicinity of Storeville, Anderson County, South Carolina, several crystals of a highly hydrated fergusonite have been found, some of which might more properly be termed an "yttro-gummite." Corundum, garnet and columbite were also observed to exist quite commonly in the region.

From near Spruce Pine, Mitchell County, North Carolina, I have received several ounces of very fair crystals of fergusonite exhibiting externally various stages of alteration. It is said to have been found in the dump heaps of the Grassy Creek Mica Mine. As a contact association I have found allanite and cyrtolite. The basal plane was prominent. One crystal weighed over twenty grams. Its behavior upon ignition was very characteristic and in all respects similar to the Texas mineral.

In the early part of last year I observed this species as a quite frequent occurrence in the gold placers of the mines near Golden P. O., Rutherford County, N. Carolina; with such associates as xenotime, malacon, monazite, rutile, etc.

On the "Orangite" from Landbö, Norway.—A partial examination of this mineral, made on several grams of transparent resin-yellow massive material, has proved it to belong to the variety of thorite called *uranothorite*, like the mineral described by Collier and the Norwegian specimens later analyzed by Lindström and by Nordenskiöld, and referred to uranothorite by Brögger. Its specific gravity = 4·322. It lost upon ignition (H_2O) 11·97 pr. ct. and contained 18·50 pr. ct. SiO_2; 52·53 pr. ct. ThO_2; 9·00 pr. ct. UO_2; 1·32 pr. ct. PbO and small amounts of lime and iron. Little if any of the cerium or yttrium earths are present, other ingredients were not looked after. It crushes into a creamy white powder which becomes dull green after strong ignition. A translucent red-brown variety, or partial alteration, has sp. gr. = 4·303.

An opaque earthy brown mineral having a black, pitchy looking core has been sent out from the same locality under the name of "thorite," but its low density (4·2) and the abundance of water, uranium and lead present, lead me to believe that it is only an impure variety of uranothorite. I have worked up over one kilogram of it and found it to contain about 45 per cent of thoria and 1 per cent of yttria earths.

14. *Tenth Annual Report of the State Mineralogist of California* for the year ending December 1, 1890. 983 pp. Sacra-

mento, 1890.—The tenth Mineralogical Report of California, issued by Wm. Irelan, Jr., State Mineralogist, is a weighty volume of nearly 1000 pages, illustrated by many plates, maps and profile sections, and accompanied by a large geological and mineralogical map of the State on a scale of 12 miles to the inch. Detailed accounts are given of the mining operations in the several counties; these chapters are contributed by a number of different observers, including W. A. Goodyear, H. DeGroot, E. B. Preston, J. B. Hobson, M. Angell, W. L. Watts and others. The colored geological map mentioned is compiled from the twenty-five atlas sheets by the State Engineering Department which are on a scale of 4 miles to the inch.

15. *Allgemeine Chemische Mineralogie* von Dr. C. DOELTER. 277 pp. 8vo. Leipzig, 1890 (Wm. Engelmann).—The fact that the author of this work has already made many important contributions to the subject of mineral chemistry both on the analytical and synthetic sides gives us a right to expect a very clear and thorough presentation of the subject from his pen and in this he has not disappointed us. The successive chapters are devoted to the general chemical relations of mineral compounds, with a discussion of isomorphism, isogonism, etc.; chemical analysis both in the wet and dry way; mineral synthesis; the alteration of minerals and their formation in nature, and finally a summary of all prominent mineral species with a statement of their composition. Of these various topics, we turn with most interest to the chapters which give an excellent summary of the present state of knowledge of artificial minerals, a subject which has been rapidly developed during the past two decades and one in which the author's contributions are not inferior to those of any other German mineralogist.

16. *Index der Krystallformen der Mineralien*, von Dr. VICTOR GOLDSCHMIDT.—The announcement of the publication numbers 4 and 5, of volume iii, made in the March number, is quickly followed by the appearance of number 6, including the species from Xanthokon to Zunyite. This concludes the work with the exception of a supplementary number which is to be devoted to errata, etc.

17. *Gray's Manual of Botany;* reprint of the sixth edition, edited by Dr. SERENO WATSON and Prof. J. M. COULTER, 1891. —In the revision of Gray's Manual which appeared about a year ago, the editors earnestly solicited information of any additions or corrections which might appear necessary. In generous response to this request a number of botanists in different parts of the country have reported such additional details or alterations as, from their personal observation, they judged desirable. In the second issue of the sixth edition, which has recently been put upon the market, and to which we take pleasure in calling attention, these additional details have received due recognition. A number of minor alterations have been made in the plates of the text, and are thus scattered through the work. Such changes, however, have naturally been limited; and the chief new feature

of the reprint is a supplement of four pages, containing over a hundred additions and corrections. Among these changes, those very naturally predominate which extend the geographical range of species and varieties. Two genera, *Franseria* and *Paulownia*, and some dozen species and varieties have been added, being chiefly introduced plants, which have escaped from cultivation within the limits of the Manual. As book-dealers still have a part of the first issue to dispose of, persons especially desiring the corrected reprint should be careful to secure copies containing the four pages 735*a*, *b*, *c*, and *d*. B. L. R.

18. *Hypertrophie des lenticelles chez la pomme de terre et quelques autres plantes ;* (Bull. soc. bot. de France, ser. II, tome xiii, pp. 48–50).—In this brief communication to the French botanical society H. DEVAUX gives an account of a remarkable modification in the development of lenticels when submerged in water. His experiments were chiefly made upon growing tubers of the potato. These he found were "asphyxiated" if completely submerged, but would live and continue their development if only partially covered with water. In the latter case, however, the lenticels, which are rather numerous, underwent a peculiar modification, increasing considerably in size, becoming conical, and opening so that a loose tissue protrudes from within. The interesting feature in the description is that the loose tissue thus formed closely resembles that modification of cork which normally occurs in certain swamp plants, and which H. Schenk has called *aerenchyma*. It is a secondary tissue characterized by thin-walled cells but slightly attached to one another and separated by very large intercellular spaces filled with air or other gases. As Dr. Schenk has shown, this tissue probably plays an important part in the aeration of submerged or partially submerged plants. The production of the same sort of tissue in the lenticels of the potato, as described by Devaux, appears therefore an especially interesting example of the power of adaptation, which a plant may exhibit when placed in unusual conditions of growth. B. L. R.

19. *The Nursery-Book, a complete Guide to the Multiplication and Pollination of Plants ;* by Prof. L. H. BAILEY. (New York, 1891, 16mo, 300 pp.)—In this neat little volume the author gives concise descriptions of the numerous forms of artificial reproduction practically applied in the cultivation of plants. The various methods of grafting, layering and propagation by division receive their proper attention, and details of manipulation and appliances for work are illustrated by numerous wood-cuts. In an extended alphabetic list of cultivated plants the best methods of propagation to be employed in individual cases are enumerated, together with valuable hints in regard to proper treatment. The closing chapter deals rather briefly with artificial pollination and hybridization. The whole work is a model of clearness and practical simplicity which will make it a valuable aid alike to professional nurserymen and to amateurs in plant-culture. B. L. R.

20. *Die Organisation der Turbellaria Acœla*, von Dr. LUDWIG VON GRAFF, Professor of Zoology and Comparative Anatomy in the University of Gratz. 90 pp. quarto. Leipsic, 1891 (Wilhelm Engelmann).—This work is an elaborate memoir on the Acœlous Turbellarian worms. It is illustrated by ten plates, exhibiting their microscopic structure as presented in different species of the genera Amphichœrus, Convoluta, Aphanostoma, Monoporus and Proporus. An especially interesting part of the volume is a supplement, on the structure and purpose of the chlorophyll cells of *Convoluta Roscoffensis*, by Dr. G. Haberlandt, Professor of Botany in the same university.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Note on the recent eruption of Kilauea, Hawaii.*—A letter, from Rev. E. P. BAKER, of Hilo, dated March 8th, states the following facts:

The eruption, or discharge of Halemaumau, mentioned on page 336, occurred on the 6th of March—the very same day of the year with that of 1886, making the interval just five years, and adding another to the number of Spring or wet-month eruptions. The lava ran out by some subterranean channel, at a slower rate than in 1886, a little of it still remaining on the 7th. The whole area gradually subsided and in two or three days, the cone had sunk out of sight, leaving in its place a crater-like cavity about as deep as that of 1886 [900 feet]. This crater has a talus halfway up from the bottom, making it conical below, and a sheer precipice above; and avalanches from the precipice continue to add to the talus. The diameters of the crater are by estimate three-fourths and half a mile.

There were earthquakes in Hilo for a week or so after the 6th of March, and many also in Kapapala, 15 miles to the southwest of Kilauea, but all were light. It is inferred that the lava ran out under ground, in the direction of the discharge of 1823. As in 1886, none appeared above ground. [The cone that was so deeply buried at the eruption was the "debris-cone," whose condition for 1887–1888 is represented on plates in Vol. xxxv of this Journal, and also in the writer's work on Volcanoes. It was early described by F. S. Dodge as resting on the liquid lava; and to this its whole history, and the final event of its burial, attest. J. D. D.

2. *Depths of* 3000 *fathoms and more in the Indian Ocean.*—An area having depths of 3000 fathoms and more exists off the Northwest coast of Australia. In addition to earlier observations between meridians of 100° and 106° E., and parallels of 18° and 25° S. new results were obtained in 1888 by the Eastern Telegraph Co.'s steamship "Recorder," under Capt. C. O. Madge. The depths found were from 3015 to 3393 fathoms, between the latitudes 13° 40′ and 11° 22′, and the meridians 118° 42′ and 116°

50′. The greatest depth was at the northeast extremity of this line, in latitude 11° 22′ and longitude 116° 50′. Just beyond, in latitude 11° 08′ and longitude 116° 38′, the depth found was 2860 fathoms.—*From the Report on Oceanic depths, issued by the Admiralty, Hydrographic Department*, London, Jan., 1891.

3. *Catalogue of the Crawford Library of the Royal Observatory, Edinburgh.* Edinburgh, 1890. This quarto of 500 pages in double columns contains the titles of the remarkable collection of books, pamphlets and manuscripts which the Earl of Crawford presented in 1888 to the Edinburgh Royal Observatory. Charles Babbage was a famous collector of rare and old books, and after his death his entire library was bought by Lord Crawford, in 1872, and to this were added rare books from the library at Haigh Hall and many other books, by purchase, so that this collection at Dunecht had become one of the notable astronomical libraries of the world. In the present catalogue the full title is given of each book and pamphlet, and the Edinburgh Observatory and its Astronomer Royal, Mr. Copeland, have thus added largely to our resources in the Bibliography of Astronomy.

4. *Dr. Goodale in New Zealand.*—The third session of the Australasian Association for the Advancement of Science was held in Christ Church, New Zealand, and began Jan. 15th, 1891. Sir James Hector, presided. The meeting was a successful one, the attendance being about 470, and the number of papers read 74. Prof. Goodale, of Harvard University, represented the American Association, but no member of the British Association attended from England.—*Nature*, March 26th.

5. *Missouri Geological Survey.*—Mr. Chas. R. Keyes of Des Moines, Iowa, has been appointed paleontologist of the Survey. Mr. Keyes is now at the Johns Hopkins University, Baltimore, but will report for duty in Missouri during the month of May. In the meantime he is occupied in the preparation of a report on the paleontology of the State, in which work he has already made considerable progress.

The Journal of Comparative Neurology: A quarterly periodical devoted to the Comparative study of the Nervous System. Edited by C. L. Herrick. Vol. I, pp. i–xviii, 1–106. Cincinnati, Ohio.

A Journal of American Ethnology and Archæology.—Editor J. Walter Fewkes. Volume I. 132 pp. 1891 (Boston and New York, Houghton, Mifflin & Co.)

OBITUARY.

James B. Mackintosh, of New York City, died on April 15th, after a brief illness, aged 34 years. He was a skillful, active chemist, and besides work on the technical side he had made important contributions to mineralogical chemistry and his future promised bright in this direction; recent volumes of this Journal contain a number of articles by him and one of which he is part author appears in the present number.

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DANA'S WORKS.

IVISON, BLAKEMAN, TAYLOR & CO., New York.—**Manual of Geology,** by J. D. DANA. **Third Edition,** 1880. 912 pp. 8vo. $5.00.—**Text-book of Geology** by the same. **4th ed.** 1883. 412 pp. 12mo. $2.00.—**The Geological Story Briefly Told,** by the same. 264 pp. 12mo. 1875.

J. WILEY & SONS, New York.—**Treatise on Mineralogy,** by J. D. DANA. 5th edit. xlviii and 828 pp. 8vo., 1868. $10.00. The 5th "subedition" was issued by Wiley & Son in April, 1874. (Each "subedition" (or issue from the stereotype plates), contains corrections of all errors discovered in the work up to the date of its publication). Also, Appendix I, by G. J. Brush, 1872. Appendix II, 1875. Appendix III, 1882, by E. S. Dana.—**Manual of Mineralogy & Lithology,** by J. D. DANA. 3d edition. 474 pp. 12mo., 1878.—**Text-book of Mineralogy,** by E. S. DANA. Revised edition. 512 pp. 8vo., 1883.—**Text-book of Elementary Mechanics,** by E. S. DANA. 300 pp. with numerous cuts, 12mo., 1881.—**Manual of Determinative Mineralogy,** with an Introduction on Blow-pipe Analysis, by GEORGE J. BRUSH. 8vo., 2d ed. 1877. Third Appendix to Dana's Mineralogy, by E. S. DANA. 136 pp. 8vo. 1882.

DODD & MEAD, New York.—**Corals and Coral Islands,** by J. D. DANA. 440 pp. 8vo, with 100 Illustrations, several maps and colored plates. 3d ed., 1890.—**Characteristics of Volcanoes,** with contributions of facts and principles from the Hawaiian Islands, by J. D. DANA. 399 pp. 8vo. With illustrations, maps, etc. 1890.

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